SOLUBLE PHOSPHORUS AND NITRATE TRANSPORT BY MONITORING GROUND WATER AND STREAM FLOW DISCHARGES IN THE NEW YORK CITY SOURCE WATERSHEDS

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SOLUBLE PHOSPHORUS AND NITRATE TRANSPORT BY MONITORING GROUND WATER AND STREAM FLOW DISCHARGES IN THE NEW YORK CITY SOURCE WATERSHEDS

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Agricultural areas are assumed to contribute excessive nutrients to surface and ground water. However, little research has explored the impact of agricultural activity on alluvial valley soils in mountainous terrain. Soluble reactive phosphorus (SRP) and nitrate-N (NO_3^--N) concentrations were measured in 37 groundwater sampling wells, and 11 locations in two streams in an alluvial valley farm in the Catskill Mountains of New York State to assess the impact of agricultural activity on stream water quality. During the study period the farm implemented several near stream best management practices (BMPs), which allowed comparative analysis of the impact of BMPs on water quality.

Analysis of measured SRP concentrations from shallow wells indicated that groundwater concentrations in the near stream area were not correlated with the in-stream concentrations. Despite over 100 years of manure application on the study farm stream SRP concentrations were generally below 0.1 mg L^{-1}, with an average of 0.037 mg L^{-1}, significantly less than those reported from surrounding hillside farms. The highest SRP concentrations were consistently measured at the shallowest groundwater depths. The NO_3^--N concentrations varied from the detection limit of 0.05 to 5 mg L^{-1}

with an average of 2.2 mg L^{-1} similar to levels reported from other agricultural areas in the Catskills.

The implementation of near stream BMPs, consisting of exclusionary fencing and cattle crossings, resulted in a 33% reduction (0.008 mg L^{-1}) in stream SRP concentrations during the growing season. There was no detectable effect of the BMPs during the non-growing season. The NO_3^--N concentrations did not appear to be influenced by the BMP.

The spatial variability of groundwater SRP indicated that SRP concentrations increased as the distance to the streams decreased. There was no a good relationship between concentrations in the groundwater riparian areas near stream and the stream itself where the SRP concentration in the groundwater around the stream was much greater than that in the stream. Temperature throughout the soil profile and depth to the groundwater table played an important role in the temporal availability of SRP in groundwater.

BIOGRAPHICAL SKETCH

Francisco Flores-Lopez was born in Mixquiahuala Hidalgo, México. As a son of a farmer, he had the wonderful opportunity of learning from his Dad how to cultivate the land and always playing with "agua". He graduated from Universidad Autónoma Chapingo in 1995 with a B.S. in Agronomy Engineering, specialized in irrigation. Shortly after graduation, Francisco enrolled himself at the Colegio de Postgraduados, where he received a M. Sc. in Water Resources Engineering in 1998. Lastly, he joined the Mexico Country Program of the International Water Management Institute where he served as a research assistant on various projects of applied water resources engineering. Two years later he came to Ithaca, NY to learn English, and subsequently join the graduate student body at Cornell University to embark on a Ph.D. Program in Soil and Water Engineering in the Department of Biological and Environmental Engineering.

This dissertation is dedicated to my parents, Jesús Flores Trejo and Reyna López Ramírez, for all the love and support they have provided me throughout my life.

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I would like to thank the farm family for allowing me to conduct this research project on their farm. I am also indebted to Larry Geohring for his assistance and advice to set up the field work.

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CHAPTER 1

ASSESSING PHOSPHORUS AND NITRATE CONCENTRATIONS IN GROUNDWATER ON A VALLEY FARM IN THE NEW YORK CITY SOURCE WATERSHEDS

1.1 Introduction

The USDA-NRCS STATSGO database indicates that there are nearly 82 million ha of land in the US with a restrictive layer at some depth in the soil profile. These layers can cause the development of seasonal perched water tables. Restrictive layers in the soil profile dominate the hillslope hydrology in Catskill Mountains in New York State. However, little is known about the impact of these physiographic conditions on water quality in valley bottom lands. There have been several studies examining the spatial and temporal scale exchanges of water across the mountain-to-valley transition (Sauer *et al.*, 2005; Gburek *et al.*, 2006; Covino and Mcglynn, 2007; Inamdar and Mitchell, 2007; Vidon and Smith, 2007). Brooks *et al.* (2004) studied soil hydraulic properties (e.g. lateral saturated hydraulic conductivity) at the hillslope-scale above a moderately deep sloping restrictive layer, and McDaniel *et al.* (2008) studied the linkages between fragipans, perched water tables and catchment-scale hydrological processes in shallow soils, but little is known about the effects in water quality. Consequently elevated nutrient concentrations in streams have led to the establishment of TMDLs (total maximum daily loads) that, if exceeded can result in restricted watershed activities. Meeting these TMDLs and improving water quality requires an understanding of watershed processes, particularly the interaction between hydrologic and biogeochemical processes (McDowell and Sharpley, 2001a; Burt and Pinay, 2005).

In undulating terrains such as those found in the Northeast US, surface runoff, groundwater flow, and the transport of both P and N over and through the soil profile is mainly a function of topography (McDowell and Sharpley, 2001b). Infiltrated water, often times carrying dissolved P and NO_3^--N, moves from areas of higher elevation to areas of lower elevation where the water can exfiltrate, sometimes forming a saturated area in the landscape that can serve as a concentrated runoff source area (Gburek *et al.*, 2002). During low rainfall periods streams are fed mainly by subsurface groundwater flow. In agricultural areas dissolved P concentrations in interflow can reach levels of several hundred μg L^{-1} (Driescher and Gelbrecht, 1993; Gérard-Marchant *et al.*, 2005), which causes eutrophication (Owens *et al.*, 1998). When P concentration in the NewYork City's Cannonsville Reservoir exceeds the 20 μg L^{-1}, strict development controls in the watershed take effect (New York State Department of Environmental Conservation, 2000). Low nitrate (< 3 mg L^{-1}), are of concern as well since the reservoir has, in the past, shown a tendency to nitrogen limitation on algal production during mid-summer (Effler and Bader, 1998). Consequently, even if point discharges and sediment sources of P or N are eliminated, groundwater discharge alone may exceed critical thresholds (Driescher and Gelbrecht, 1993; Burkart *et al.*, 2004).

Several researchers have attempted to quantify the contribution of N and P from the various pathways (surface, interflow or groundwater). High intensity sampling during rainfall events in two contrasting sub-catchments in England by Evans and Johnes (2004) showed that the lowest concentrations of dissolved P were observed during baseflow periods (i.e., no surface runoff). Weiler and McDonnell (2006) noted that when the water table rises to, or near, the soil surface, nutrients (such as N and P) are mobilized from surface layers by lateral flow, which may exfiltrate in low lying areas of the landscape or near the stream channel (Scott and Weiler, 2001) ultimately mobilizing the nutrients. Thus, it is unclear whether the source of the nutrients transported to streams originates from the subsurface (groundwater) or surface (runoff), some combination of the two (interflow), or all of the above. Furthermore, under saturated conditions, the soil can become anaerobic resulting in increased P solubility and NO_3^--N denitrification, adding further to the complexity of the biogeochemical interactions (Knowles, 1982). This coupled with the fact that many of these pollutants interact with other constituents in the subsurface (e.g., SRP with dissolved organic carbon (DOC), dissolved oxygen (DO), and NO_3^--N) that are themselves poorly understood, constitutes a critical knowledge gap in our overall understanding of the system.

The objective of this research is to evaluate SRP and NO_3^--N concentrations in shallow groundwater in agricultural valley bottom lands surrounded by mountainous topography where depositional alluvial soils are utilized for intensive agricultural. This research focused on (i) enhancing the understanding of the interaction dynamics of SRP and NO_3^--N in subsurface flow, as SRP and NO_3^--N concentrations are affected by manure application, water table depth, time of the year, and the concentrations of DO and DOC in groundwater; and (ii) quantifying the effectiveness of riparian areas in reducing groundwater SRP and NO_3^--N contributions to a valley stream.

The study was conducted from November 2003 to April 2006 on a dairy farm located on alluvial plains in the Catskill Mountains of New York State, just upstream of the Cannonsville Reservoir which supplies drinking water to New York City. The research is applicable to many areas of the landscape with alluvial soils, particularly in the valley bottom areas of the Northeast US.

1.2 Material and Methods

1.2.1 Study Site

The dairy farm is located along a lowland tributary of the West Branch of the Delaware River, which drains approximately 5% of Cannonsville Reservoir watershed. The farm (Fig. 1.1) encompasses 19 ha of valley bottom land parallel to the stream and 119 ha of uphill lands (not shown in Fig. 1.1) dominated by deciduous forest. Of the 19 ha of valley bottom land, 10 ha is managed as corn and 9 ha as alfalfa in a 3-4 year rotation. In June 2005 the land use changed in the southern area of the farm on approximately 4 ha, from alfalfa to corn land for the remainder of the study (Fig. 1.1). The farm has participated in whole farm planning since September 1995 as part of the Watershed Agricultural Program established by the New York City Department of Environmental Protection (NYCDEP), the New York State Department of Environmental Conservation (NYSDEC), the Watershed Agricultural Council, and the Environmental Protection Agency.

The farm was chosen because a shallow groundwater table exists in the valley bottom for much of the year, particularly in the southern area of the farm (Fig. 1.1). Several springs are located either at the base of where the steep surrounding hillslopes flatten or in the valley itself, and are active for the majority of the year except at droughty times in the summer. Small creeks originate from the springs and drain into the main stream, which flows from north to south (Fig. 1.1). In the southern area of the farm, where the open ditch (labeled as Creek B in Fig. 1.1) starts, regional groundwater intersects the surface and forms saturated areas during October - May when precipitation exceeds evapotranspiration.

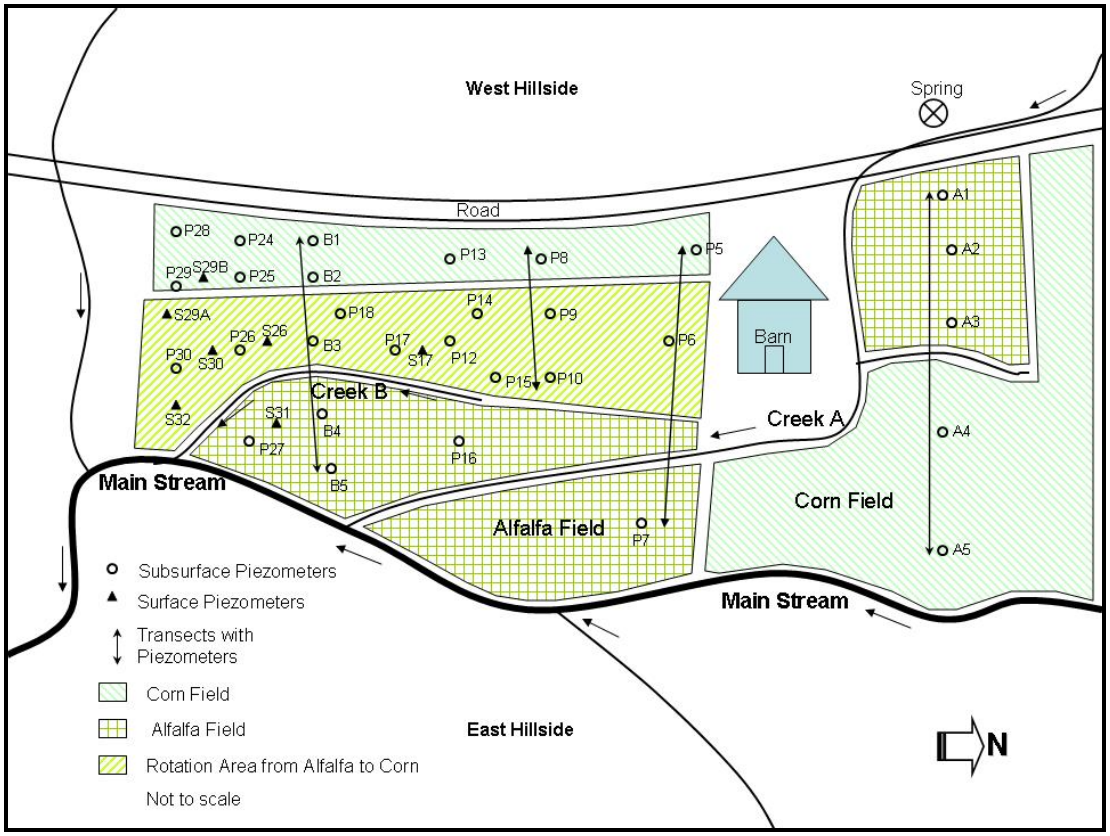


Figure 1.1 A schematic diagram of experimental area within the lowland daily farm. Piezometers are indicated by a letter and number. The A and B piezometers were placed during the fall (October) of 2003. Piezometers P5 to P12 plus P18 were placed during early summer (July) of 2004 and P13 to P30 in October 2004. Surface piezometers are identified by a capitol S and a number.

The soils in the valley bottom are mainly comprised of alluvial soils of the Barbour-Trestle complex (Coarse-loamy-skeletal over sandy or sandy-skeletal, mixed, active, mesic Fluventic Dystrudepts); the principal water-bearing material is Pleistocene sand and gravel (Soren, 1963). Overland flow is generally absent because of high infiltration rates in these alluvial soils. Depth to the bedrock is estimated to be about 18 m (Soren, 1963). The underlying bedrock is predominately consolidated sandstone, siltstone, and shale, covered by gravel, sand, unconsolidated fill, and clay.

The climate of the Cannonsville Reservoir watershed is humid continental with an average temperature of about 8ºC. The annual average precipitation is 112 cm yr^{-1} (National Climatic Data Center, 2000) of which approximately one-third falls as winter snow. The growing season is from May to October. The nearest weather station is located in Walton, NY approximately 9 km to the southeast of the field site.

In 2004, the farm had 60 adult dairy and beef cows and 36 heifers. About eighty percent of the manure was applied on the valley bottom lands with an average rate of 35 Mg ha^{-1} during the winter. During the remainder of the year, the dairy herd grazes in the pastures; thus, less manure is produced in the barnyard and about twenty percent of the 833 Mg (ton) of manure that is produced annually is randomly deposited in the pasture.

1.2.2 Groundwater Sampling

Based on information collected during the study, the project design evolved over the course of the research (2003-2006). A total of 37 subsurface piezometers were installed: Thirty piezometers with depths from 0.3 to 1.5 m and seven surface piezometers with a maximum depth of 30 cm. The piezometers were made of PVC pipe, 3.5 cm in diameter; with a screened length of 0 - 0.3 m from the bottom and wrapped with geosynthetic filter cloth. Piezometers were closed at the bottom. Piezometers were installed by auguring a hole with a diameter slightly larger than piezometer. The piezometers were then sealed with bentonite at the top. Initially, during the fall of 2003, two transects of subsurface piezometers were installed in the field at two locations, one in the northern field and one in the southern field (Fig. 1.1). Both transects were placed perpendicular to the stream with an east-west orientation and crossed the corn and alfalfa fields. Each transect had five piezometer nests (Fig. 1.1) with two piezometers installed at each location with screened depths at 0.3 - 0.6 m and at 0.8 - 1.2 m. Sampling began 5 November, 2003.

During early summer of 2004, eight more subsurface piezometer sampling locations were established. These eight locations were placed in two more transects distributed between the initial two transects and perpendicular to the stream as well (Fig. 1.1). The screened depths of these new piezometers ranged from 1.2 m to 1.5 m. Sampling of these new locations began on 19 July, 2004. In the fall of 2004, 12 more piezometer sampling locations were added in the southern field of the farm where the groundwater table is closer to the surface. The depths of these piezometers ranged from 0.6 m to 1.0 m and sampling of these locations began on 4 November, 2004 (Fig. 1.1). In December 2004 seven more single piezometer sampling locations were installed in the southern area of the farm where the groundwater table often intercepts the soil surface when precipitation exceeds evapotranspiration. These seven surface piezometers were distributed in the saturated areas and the depths ranged from 0 - 0.3 m. The sampling period for these piezometers was December 2004 to April 2005. The data from these surface piezometers are discussed in the context of the observed concentrations but were not included in the statistical analysis due to the short sampling duration.

1.2.3 Soil Analysis

Composite soil samples were collected at 25 sampling locations in July 2004 at two depths: 0 to 5 cm and 6 to 15 cm. Eighteen samples were collected from the corn field and seven samples from the alfalfa field. The soil was analyzed for Total P using $Mg(NO_3)_2$ ashing method (Tadon *et al.*, 1968) at Cornell Nutrient Analysis Laboratory.

1.2.4. Groundwater Height and Flow Direction

Groundwater table heights were determined at a frequency of 1 hr with 0.5 m or 1 m long capacitance probes (TruTrack, Inc, New Zealand) (resolution of 1 mm) at 30 locations adjacent to existing piezometers (Fig. 1.1). The first 15 capacitance probes were installed in July 2004, and the remaining 15 during the fall of 2004 in the southern area of the farm where the groundwater table is shallow (Fig. 1.1). Reference piezometer elevations were taken with a laser survey.

The general groundwater flow direction, assuming steady state flow, was determined based on the measured water table heights for the southern area of the study site where 22 water level loggers were installed (P8 to P30 in Fig. 1.1). Equipotential lines were defined for steady state groundwater flow conditions averaged over a 672 days period (from June 6, 2004 to April 30, 2006). The 18 m depth of the bedrock (impermeable) layer was assumed constant based on measurements from a domestic well located 1 km to the north (Soren, 1963), and the topography was derived from the 10-m digital elevation model obtained from the Cornell University Geospatial Information Repository.

1.2.5 Water Chemistry Analysis

Groundwater samples were collected at least bimonthly, although occasionally more frequently, from November 2003 through April 2006. Samples were collected using a peristaltic pump rinsed with distilled water before each use. A volume of 100 ml of water was collected in pre-cleaned plastic bottles. Piezometer purging was done prior to sample collection. The pump's output tube was kept in the sampling bottle for the entire pumping duration to allow the groundwater to be well mixed, and to prevent water contact with ambient air during pumping. Water samples were collected with no headspace and stored in coolers to prevent temperature increases during transport to the laboratory.

The DO concentration was measured directly in each bottle using a Traceable ® Digital Oxygen Meter (Fisher Scientific) within 3-4 hr of sampling. Testing showed that there was no significant difference between DO measurements taken in the field and laboratory. Dissolved oxygen concentration readings were started on January of 2005. After measuring the DO concentration, samples were filtered through 0.45 µm membrane filters.

The filtered samples were analyzed beginning November 5, 2003 for SRP within 24 hours of sampling, or were stored in a refrigerator at 4°C until they could be analyzed. The samples were analyzed using the OI Analytical FlowSystem 3000 Automated Ascorbic Acid Method for SRP.

Filtered groundwater samples were analyzed for NO_3^--N beginning in the spring of 2004 with the spectrophotometric method and Spectronic 501 instrument by Bausch &

Lomb (Cataldo *et al.*, 1974). Nitrate-N analyses were done for all samples except for those samples collected during winter where initial analysis indicated that NO_3^--N concentrations were below the detection limit (0.05 mg L^{-1}). Dissolved Organic Carbon analyses were conducted starting in January, 2005 using the IO Analytical Model 1010 Total Organic Carbon Analyzer (IO-Analytical, 1997).

1.2.6 Statistical Analysis

Analyses of variance (ANOVA) and mixed model analyses were performed with SPSS (SPSS Inc., 2006). The mixed model expands on the general linear model by allowing correlation and non-constant variance among variables, although normality is assumed. The basic assumption is that the data are linearly related to multivariate normally distributed random variables (Littell *et al.*, 1996). Our mixed model contained fixed and random effects. Fixed effects are variables for which the only levels under consideration are contained. Random effects are variables for which the levels represent a random sampling of all possible levels in the population of that variable. In the estimate of fixed effect output there are main effects which are linear explanatory values, and interaction effects which combine the effects of the components main effects.

Two separate mixed model analyses were performed on natural log transformed SRP or NO_3^--N groundwater concentrations as the response variables. Each model used the same fixed and random effect independent variables (Table 1.1). Independent fixed effect variables were sampling date, spatially averaged groundwater depth, DO and DOC sample concentrations, total rainfall on the day before and on the day of sampling, manure application, and land cover. Sampling dates were grouped in four categories: fall, winter, spring, or summer. Manure spreading records were only available on a field basis. Therefore, if manure was spread on the field where the sample was taken during the season it was sampled, it was coded as one otherwise it was a zero. Land covers were alfalfa and corn (Table 1.1). Random variables were the 30 sampling locations. Initially the two model runs were made using all main and interaction effects among variables. Model variables were selected using all subsets regression, and forward and backward regression methods. Main and interaction effects significant at α=0.1 were retained in the models. In addition, any main effects that were significant in interactions were retained in the model regardless of significance.

Table 1.1 Variables included in the mixed model analysis.

Variable	Abbreviation	Units	Variable Type	Parameter
Ln[Soluble Reactive Phosphorus]	SRP	mg L^{-1}	Continuous	Dependent
Ln[Nitrate-N]	NO_3-N	mg L^{-1}	Continuous	Dependent
Seasons †	Season	n/a	Categorical	Fixed-Effect
Groundwater Table Depth	GWT	m	Continuous	Fixed-Effect
Dissolved Organic Carbon	DOC	mg L^{-1}	Continuous	Fixed-Effect
Dissolved Oxygen	DO	mg L^{-1}	Continuous	Fixed-Effect
Rainfall ‡	RF	cm	Continuous	Fixed-Effect
Manure Spreading Records §	SpdM	n/a	Categorical	Fixed-Effect
Land Cover ¶	LndCv	n/a	Categorical	Fixed-Effect
Sampling Site #	Site	n/a	Categorical	Random-Effect
Season by Year ††	Season + Year	n/a	Categorical	Random-Effect

† Sampling dates were grouped by season, fall, winter, spring, and summer.
‡ Observed rainfall during the previous day and the day of sampling being in total 2 days of rainfall.
§ Manure spreading record is coded as 0 or 1. 1 = manure was spread during the current season. Otherwise = 0.
¶ Land cover is coded as 1 or 2. 1 = corn field. 2 = pasture field.
 # Sampling site locations in the field where groundwater samples were taken: n = 30 (Fig. 1.1).
†† Season by year are coded as follows: 1 = fall 2003, 2 = winter 2003/04,…., 11 = spring 2006.

1.3 Results

The spatially average groundwater table depth over the project period was 0.6 m (Table 1.2), and was closest to the surface in the southern field. The maximum groundwater depth was measured during summer and the minimum during spring (Table 1.2). The response to rainfall was similar for all wells. The direction of the steady state groundwater flow derived from the apparent equipotential lines was predominately north-to-south in the northern area and northwest-to-southeast in the southwestern quadrant area (Fig. 1.2) where the valley bottom converges with the steep hillside.

The average concentration in the shallow groundwater below 0.3 m was 0.041 mg L^{-1} SRP, 2.2 mg L^{-1} NO_3^--N, 3.8 mg L^{-1} DOC and 3.7 mg L^{-1} DO (Table 1.2). The average concentration in the seven shallow wells (< 0.3 m) in the southern area of the field (S17, S26, S29A, S29B, S30, S31, S32 in Fig. 1) was 1.3 mg L^{-1} DO, and had greater SRP (0.145 mg L^{-1}) and DOC (24 mg L^{-1}) concentrations than locations were the ground water table was deeper. Fall concentrations were generally greater than during the other times of the year (NO_3^--N, DOC, and DO were significantly different ($p < 0.001$) but SRP that was not significantly different ($p = 0.219$)). Our SRP concentrations are generally less than those reported by Carlyle and Hill (2001) in a river riparian zone in Ontario, Canada with ranges of SRP between 0.05 – 0.95 mg L^{-1}. Average NO_3^--N (mean of 1.0 mg L^{-1}) and DOC (mean of 2.1 mg L^{-1}) concentrations in Creek B are lower than in the average groundwater concentrations. The mean SRP concentration of 0.037 mg L^{-1} was similar to that in groundwater for SRP, and the average DO concentration (5.4 mg L^{-1}) was greater.

Table 1.2 Overall descriptive statistics by seasons for all dataset records of soluble reactive phosphorus (SRP), nitrate-N (NO_3^--N), dissolved organic carbon (DOC) and dissolved oxygen (DO) concentrations and groundwater table depth.

Season	Statistics		SRP	NO_3^--N	DOC	DO	Groundwater Table Depth
			mg L^{-1}				m
Fall	Mean		0.047	3.9	4.7	4.4	0.61
	Std. Error		0.005	0.7	0.8	0.2	0.03
	Std. Deviation		0.074	5.8	7.8	1.5	0.32
	Maximum		0.536	28.3	69.6	9.0	1.54
	n		227	61	86	96	167
	% of Total n		33	29	21	25	33
Winter	Mean		0.036	n.d.	3.8	4.4	0.61
	Std. Error		0.004	n.d.	0.4	0.2	0.03
	Std. Deviation		0.055	n.d.	4.7	2.5	0.31
	Maximum		0.383	n.d.	44.7	11.2	1.46
	n		158	n.d.	125	102	95
	% of Total n		23	n.d.	31	26	19
Spring	Mean		0.040	1.8	3.5	3.1	0.50
	Std. Error		0.007	0.2	0.4	0.1	0.30
	Std. Deviation		0.092	1.7	5.5	1.0	0.03
	Maximum		0.961	10.6	29.4	4.9	1.41
	n		182	67	153	152	147
	% of Total n		27	32	29	39	29
Summer	Mean		0.038	1.3	3.2	3.1	0.72
	Std. Error		0.005	0.2	0.6	0.2	0.03
	Std. Deviation		0.056	1.8	3.7	1.0	0.34
	Maximum		0.354	8.4	16.7	4.8	1.54
	n		120	84	38	38	102
	% of Total n		18	40	10	10	20
Total	Mean		0.041	2.2	3.8	3.7	0.60
	Std. Error		0.003	0.2	0.3	0.1	0.01
	Std. Deviation		0.073	3.6	5.7	1.8	0.33
	Maximum		0.961	28.3	69.6	11.2	1.54
	N		687	212	402	388	511
	Percentiles	25	0.012	0.4	1.0	2.8	0.35
		50	0.020	1.2	2.0	3.5	0.57
		75	0.038	2.2	4.6	4.3	0.81

The average total P concentration in the composite soil samples was 1.04 g kg^{-1} with a maximum of 1.34 g kg^{-1} and minimum of 0.70 g kg^{-1}. Generally, soil P levels above 100 mg kg^{-1} are indicative of high P accumulation in the soil and have been associated with elevated P levels in overland flow (Kleinman *et al.*, 2000; McDowell and Sharpley, 2001a; Sharpley *et al.*, 2001).

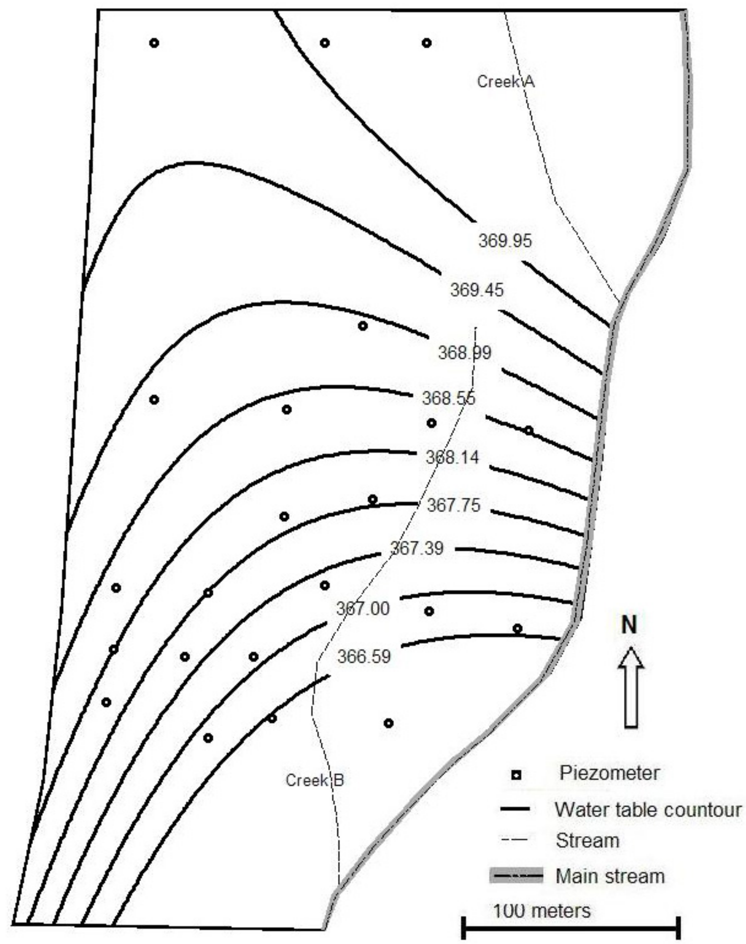


Figure 1.2 Map of groundwater table based equipotential lines for the average steady state ground water flow conditions over a period of 672 days.

The physical conditions and chemical interactions that influence SRP and NO_3^--N concentrations in groundwater are investigated by employing the mixed model analysis. Since there are no significant collinearity effects between SRP and NO_3^--N (Pearson correlation coefficient: 0.008, *p-value* = 0.907, n = 207), each of these nutrients are analyzed separately. The explanatory variables initially used in both models are listed in Table 1.1. Results of the mixed model analysis of SRP concentrations in groundwater are shown in Table 1.3 and for NO_3^--N in Table 1.4.

Table 1.3 *P-values* for main effects and interaction effects in the mixed model analysis for SRP. Estimate coefficients and their corresponding *p-values* are presented to create a regression analysis equation. Variables are explained in Table 1.1.

Effect	Variable	Estimate Coefficient	*p - value*
Main	Intercept	-4.600	<0.001
Main	RF	0.184	<0.001
Main	DOC	0.0002	0.009
Main	GWTD	1.269	0.015
Main	SpdM		0.045
	SpdM=0	-0.396	0.045
	SpdM=1	$0^{\dagger}$	
Main	Season		0.062
	Season=Fall	0.407	0.058
	Season=Spring	0.210	0.208
	Season=Summer	-0.119	0.643
	Season=Winter	$0^{\dagger}$	
Main	DO	0.100	0.253
Interaction	GWTD*DO	-0.232	0.076
Interaction	DOC(SpdM)		0.004
	DOC(SpdM=0)	0.084	0.004
	DOC(SpdM=1)	$0^{\dagger}$	

†: This parameter is set to zero because it is redundant.
Dependent variable: Ln [Soluble Reactive Phosphorous (mg L^{-1})].
Interaction effects involving at least one categorical variable are in parenthesis.
Interaction effects for continuous variables only use the start sing (*) instead of parenthesis.

Variables that are statistically significant at α=0.1 for SRP (main effects) in Table 1.3 according to the mixed model analysis are: rainfall amount on the day before sampling (RF), DOC concentration, groundwater table depth (GWTD), spreading of manure on the field during a sampling season (SpdM), and the season in which the sample was taken (Season). The DO concentration is not significant as main effect, but it is as an interaction effect with GWTD (GWTD*DO). There is also a significant interaction effect between the DOC and SpdM, (DOC(SpdM)) (Table 1.3). Note that in the nomenclature, parentheses are used for interaction effects of non continuous or categorical variables, while a star indicates interaction among continuous variables. The variables that significantly affect the NO_3^--N concentration in the groundwater

Table 1.4 *P-values* for main effects and interaction effects in the mixed model analysis for NO_3^--N. Estimate coefficients and their corresponding *p-values* are presented to create a regression analysis equation. Variables are explained in Table 1.1.

Effects	Variables	Estimate Coefficient	*p - value*
Main	Intercept	5.0994	<0.001
Main	RF	-0.7633	<0.001
Main	Season		<0.001
	Season=Fall	0.7265	0.231
	Season=Spring	-5.2573	<0.001
	Season=Summer	$0^{\dagger}$	
Main	SpdM		<0.001
	SpdManure=0	-4.3743	<0.001
	SpdManure=1	$0^{\dagger}$	
Main	DO	-0.5304	0.016
Main	LndCv		0.011
	LndCv=1	0.6623	0.011
	LndCv=2	$0^{\dagger}$	
Interaction	DO(Season)		0.012
	DO(Season=Fall)	0.5177	0.004
	DO(Season=Spring)	0.5138	0.015
	DO(Season=Summer)	$0^{\dagger}$	
Interaction	Season (SpdM)	4.7196	<0.001

†: This parameter is set to zero because it is redundant.
Dependent variable: Ln [Nitrate-N (mg L^{-1})].
Interaction effects involving at least one categorical variable are in parenthesis.
Interaction effects for continuous variables only use the start sing (*) instead of parenthesis.

(i.e., the main effects in the mixed model analysis) are: RF, Season, SpdM, DO, and land cover (LndCv) (corn or alfalfa). The interaction effects that were statistically significant were DO(Season) and Season(SpdM) (Table 1.4).

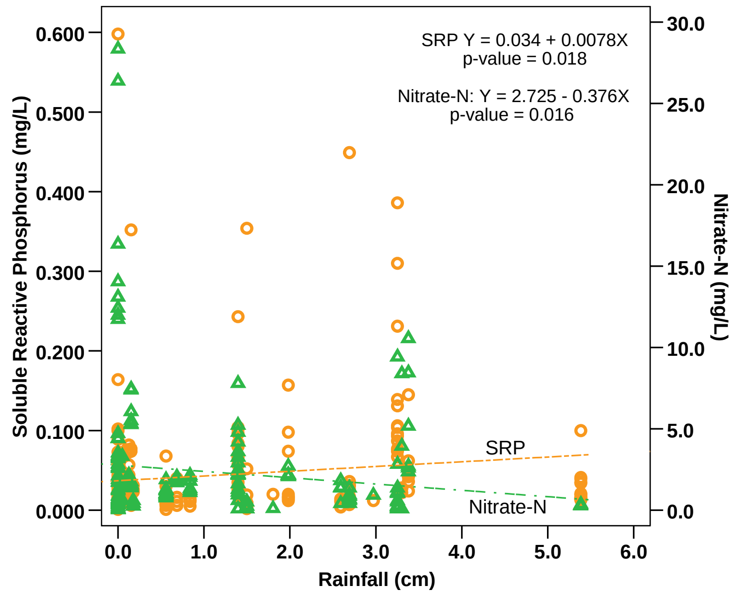
1.4 Discussion

To facilitate the discussion the closely related variables are divided in groups. These groups are: physical environmental variables, which include rainfall and groundwater depth; source factors consisting of manure additions and crop type (corn receives more manure than alfalfa); and chemical environmental variables (DOC and DO concentrations).

1.4.1 Physical Environmental Variables: Rainfall and Groundwater Depth

Although the RF main effect is highly significant for both SRP and NO_3^--N, it has an opposite effect on each, as noted by the signs of the coefficient estimates in Tables 1.3 and 1.4 (e.g., negative for NO_3^--N and a positive for SRP). Increasing rainfall increases the SRP concentration but decreases the NO_3^--N concentration (Fig. 1.3). Preferential flow, induced by rainfall, rapidly transports chemical from the surface to groundwater (Schilling and Jacobson, 2008; Steenhuis *et al.*, 1994). Although equilibrium levels of P between the soil pore water in the matrix can be established, adsorbed P moves rapidly down in the preferential flow paths without sufficient time to adsorb (Steenhuis *et al.*, 1994). Thus, SRP in the recently leached "new" groundwater is not in equilibrium with the surrounding soil and has a relatively high concentration. This SRP concentration decreases slowly by adsorption to the bulk soil after the rain (and leaching) has stopped, hence the positive correlation in Table 1.3. This is also the reason that the SRP concentrations are spatially and temporarily variable, similar to that observed by Gburek *et al*. (2002) for a field in Pennsylvania and depends on whether the sample is taken close to a preferential flow path at the time the leaching occurred (Boll *et al.*, 1991).

Nitrate on the other hand does not adsorb and travels to groundwater via both the soil matrix and preferential flow paths. Preferential flow generally has a lower NO_3^--N concentration than the soil water. The decrease in groundwater NO_3^--N concentration with increasing rainfall is likely the result of dilution of NO_3^--N leached from the root



Open circles correspond to SRP observed concentrations.
Open triangles correspond to NO_3^--N observed concentrations.

Figure 1.3 Plot of the influence of rainfall on soluble reactive P (SRP) and nitrate-N (NO_3^--N) concentrations in groundwater. Rainfall was statistically significant for both SRP and NO_3^--N concentrations. SRP concentration increases while NO_3^--N concentrations decreases as a function of rainfall.

zone (Fig. 1.3) (Burt and Pinay, 2005). Diffusion over time will equalize the concentration in the ground water, hence the negative correlation. In addition, increased rainfall is also related to increased potential for denitrification which is discussed more under the chemical environmental factors. Although there is not a clear relationship between GWTD and SRP in Fig. 1.4a, GWTD is statistically significant in the mixed model (Table 1.3). The majority of the SRP concentrations greater than 0.1 mg L^{-1} occurred when the average groundwater depth was less than 60 cm from the soil surface (Fig. 1.4a). The greatest NO_3^--N concentrations were consistently measured during the fall at shallow water table depths (Fig. 1.4b, and Fig.

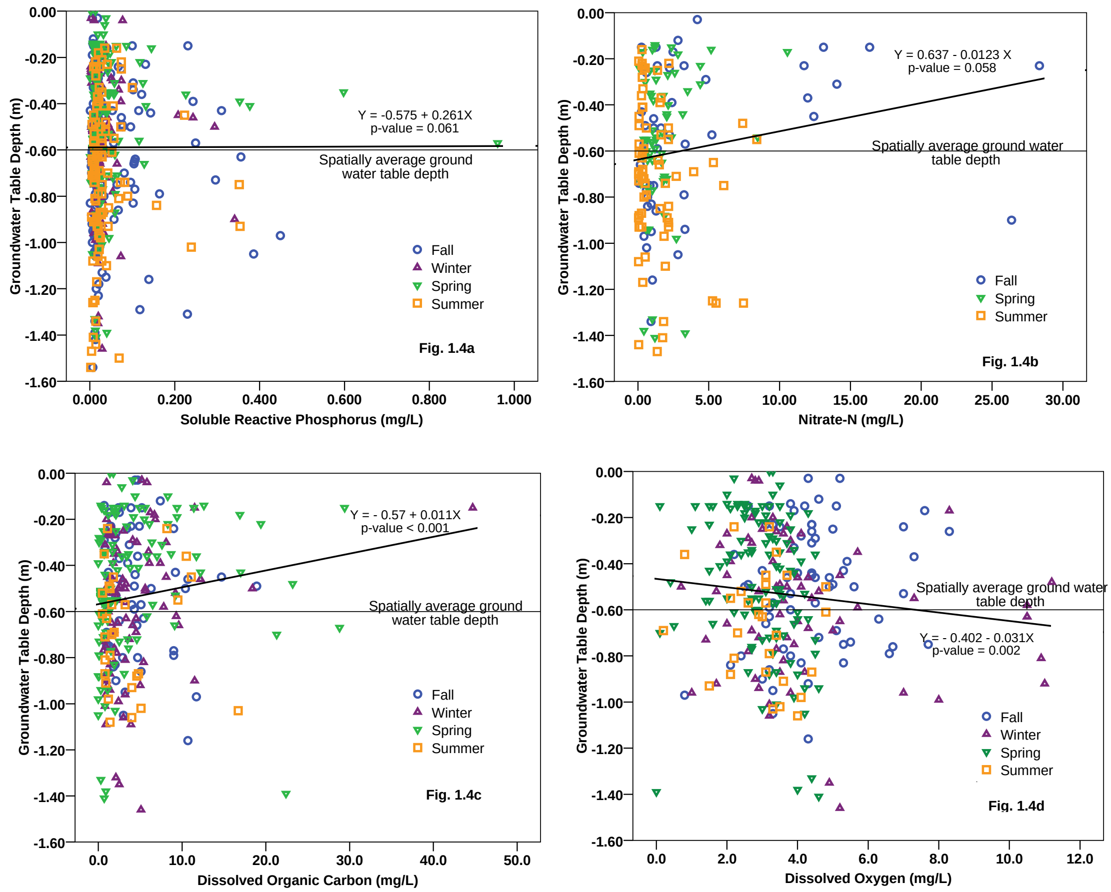


Figure 1.4 Observed soluble reactive phosphorus (SRP), nitrate-N (NO_3^--N), dissolved organic carbon (DOC) and dissolved oxygen (DO) concentrations plotted with respect to the depth to the groundwater table by seasons. Concentrations from seven surface piezometers, installed Dec 2004, are included in the respective plots. Horizontal lines indicate the spatially average ground water table depth from surface.

1.1 locations P15, P23, and P29 wells). In the southern area of the site the seven shallow surface piezometers (15-30 cm) (Fig. 1.1) confirmed the trends seen in the other piezometers that SRP (Mulholland and Hill, 1997; Pionke *et al.*, 1999). When groundwater reaches the root zone where P levels are elevated, ground water concentration will increase too.

1.4.2 Source Factors: Manure Spreading and Land Cover

Spreading of manure on the field (SpdM main effect) significantly increased the concentrations of both SRP (p = 0.045) and NO_3^--N (p < 0.001) in the groundwater, while under corn (LndCv main effect) the NO_3^--N concentration significantly greater than under the alfalfa (Tables 1.3 and 1.4). The increase in the groundwater concentrations of N and P is not un-expected since manure has a relatively large amount of SRP and readily available N (McDowell and Sharpley, 2001a; Smith *et al.*, 2001). The Season(SpdM) effect (Table 1.4) is the result of elevated concentrations during the fall and is likely caused by the leaching of accumulated solutes in the root zone during the summer months when the potential evaporation exceeds rainfall and leaching losses are small.

The LndCv main effect is illustrated in Fig. 1.5 where there is increased NO_3^--N leaching under corn, especially during the fall compared to alfalfa. The LndCv effect is a proxy for both the amount of manure applied and the amount of water available for leaching during early spring and fall because greater amounts of manure are applied to corn land than to alfalfa especially during the fall after the corn is harvested. Thus, with soil temperatures still warm and conditions conducive to nitrification and mineralization, more NO_3^--N is leached from the corn fields. Unlike NO_3^--N, which is formed rapidly via nitrification and is leached rapidly as well, P release is rather slow and can reside in the root zone for a long time. Thus, SRP leaching is independent of land cover (Table 1.3). An interesting consequence of long term manure applications is that even when applications are stopped, SRP leaching will continue while NO_3^--N losses will diminish in a relatively short time.

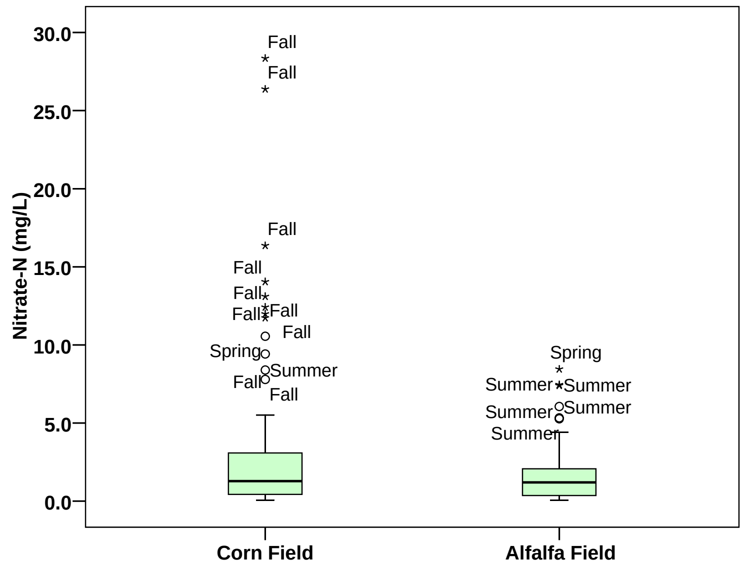


Figure 1.5 Plot of the land cover (LndCV) main effect on nitrate-N (NO_3^--N). Also shown is the seasonal affect where fall concentration in the corn field is significantly higher than in the alfalfa field.

1.4.3 Chemical Environmental Variables: DOC and DO Groundwater Concentrations

Groundwater SRP concentrations are highly correlated with the DOC concentrations (i.e., DOC main effect, Table 1.3). Both DOC and SRP concentrations are greater near the surface (Fig. 1.4a and 1.4c). Elevated DOC levels in the top soil, mainly from manure applications (as indicated by the highly significant DOC(SpdM) interaction), increase DOC leaching (Boyer *et al.*, 1997) and is likely responsible for elevated SRP concentrations (Schilling and Jacobson, 2008). The positive relationship linear relationship between the natural log transformed SRP concentrations and DOC during the fall corroborates this statement (Fig. 1.6). The fall had the greatest mean concentrations for SRP and DOC (Table 1.2).

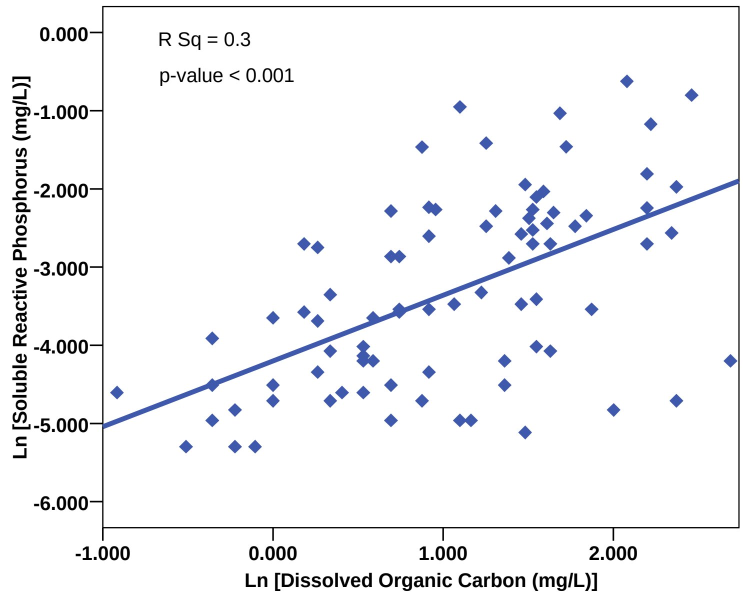


Figure 1.6 Linear regression for the natural log transformed soluble reactive phosphorus (SRP) and dissolved organic carbon (DOC) concentrations in groundwater during the fall.

The groundwater NO_3^--N concentrations were independent of the DOC and DO concentrations except during the fall when there was a distinct relationship between DO concentrations and NO_3^--N concentrations. In this period the DO concentrations were elevated when NO_3^--N concentrations are at their minimum. If denitrification was indeed the cause, then DO concentration should have been at a minimum too.

1.4.4 Season Effect

The analysis of variance showed that SRP concentrations were not significantly affected by the season in which samples were taken (p = 0.219, n = 687). Season becomes marginally significant in the mixed analysis (p = 0.062, Table 1.3) when we control for the variance of other factors. For NO_3^--N, Season remained highly significant in the mixed model analysis ($p < 0.001$, Table 1.4). It is obvious that many factors combined makeup the "season" effect including, temporal soil moisture status and temperature which are not directly included in the mixed model analysis.

1.4.5 Groundwater as a Potential Source of Pollutant Loading

Previous studies indicated that subsurface riparian flow can be an important control on SRP and NO_3^--N transport, nutrient cycling, and others loadings to streams in Iowa riparian zones (Schilling *et al.*, 2007; Schilling and Jacobson, 2008). While we only considered nutrient concentrations, instead of loads due to the lack of groundwater flows measures, the setup of the study still allows us to investigate whether riparian buffers are effective in reducing groundwater SRP and NO_3^--N contributions to a valley stream. Although the water quality in Creek A is affected by a cattle crossing, Creek B is entirely fed by groundwater (Fig. 1.1). Therefore, any significant difference between the concentrations of nutrients in Creek B and that in the groundwater is an indication of the effectiveness of the riparian buffer. Similar to other studies, the NO_3^--N concentration in stream B (mean is 1.0 mg L^{-1} over the course of the experiment) is significantly lower (p-*value* = 0.008, n = 223) than the average concentration (2.5 mg NO_3^--N L^{-1}) of groundwater sampled below the 30 cm depth in piezometers P8 to P30 (Figs. 1.1 and 1.2) during the same period. The average of 2.1 mg L^{-1} NO_3^--N for the piezometers located in the riparian buffer less than 25 m upstream of Creek B (P15, P16, P17, P21, P22, P26, P27, and P30 in Figs. 1.1 and 1.2) was also slightly below the average groundwater concentration of 2.2 mg L^{-1} NO_3^-- N but not statistically different. The in-stream NO_3^--N concentrations of Creek B of 1.0 mg L^{-1} NO_3^--N were significantly lower than the piezometers in the riparian buffer (p-*value* = 0.008, n = 123). The effectiveness of the riparian buffer in reducing SRP concentrations is not as obvious, and the lack of groundwater flow data prevents us from evaluating the complete effect of the riparian buffer. However, the average SRP groundwater concentration (0.043 mg L^{-1}) obtained from the piezometers sampled below the 30 cm depth (P8 to P30) is slightly higher, but not statistically different (p-*value* = 0.336, n = 777) from the in-stream concentration of Creek B (0.037 mg L^{-1}). The SRP concentrations (average 0.050 mg L^{-1}) in the piezometers less than 25 m from stream B in the riparian buffer and surface wells (average 0.145 mg L^{-1}) were significantly greater (p-*value* = 0.023, n = 687) than the concentrations in the piezometers at distances greater than 25 m (average 0.037 mg L^{-1}), and significantly (p-*value* = 0.046, n = 415) above the levels in Creek B. These data indicate that the shallower the groundwater, the greater the SRP concentration; and therefore, because the groundwater is closest to the surface in the riparian buffer, the SRP concentration increases in the riparian buffer compared to the groundwater that feeds it. Thus, although the creek water SRP concentrations are significantly less than in the riparian buffer, the creek water is not significantly different from the overall groundwater SRP concentrations.

1.5 Conclusions

In this research the spatial and temporal relationships of SRP and NO_3^--N concentrations were analyzed in shallow groundwater to identify the potential interactions that influence SRP and NO_3^--N concentrations in groundwater on a valley dairy farm in the Catskill Mountains in New York State.

The SRP concentrations in groundwater were 0.001 to 0.1 mg L^{-1} with an average of 0.04 mg L^{-1}, generally less than levels reported from the upland farms in the same area. The highest concentrations were found at shallow groundwater depths. The NO_3^--N concentrations varied from the detection limit of 0.05 to 5 mg L^{-1} with an average of 2.2 mg L^{-1} similar to other agricultural areas in the Catskills. Fall NO_3^--N and SRP concentrations were elevated compared to other times of the year. Closely related variables were divided into four groups. These groups were physical environmental variables, source factors, chemical environmental variables and time. The physical environmental variables consisted of rainfall and groundwater depth. Rainfall increased the SRP concentration but decreased the NO_3^--N concentration. The SRP concentrations were greater in shallow groundwater than those in deep groundwater. Source factors consisted of manure additions and crop type (corn receives more manure than alfalfa). As expected, manure application increased both the NO_3^--N and SRP concentrations in the groundwater. Higher NO_3^--N concentrations were found under corn than under alfalfa. For the chemical environmental variables (DOC and DO concentrations), groundwater SRP concentrations were correlated with the DOC concentrations. The NO_3^--N concentrations were negatively correlated with DO groundwater concentrations but only during the fall.

Observed SRP concentrations in groundwater were slighter greater but not statistically different than concentrations in a stream that was entirely fed by groundwater. Stream buffers showed elevated SRP concentrations. Nitrate concentrations in the stream were significantly less than in groundwater at any distance from the stream. Further studies should be conducted to investigate the groundwater and stream flow interaction as well as the biogeochemical controls of DOC on P mobility.

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CHAPTER 2

A MULTIVARIATE ANALYSIS OF COVARIANCE TO DETERMINE THE EFFECTS OF NEAR STREAM BEST MANAGEMENT PRACTICES ON N AND P CONCENTRATIONS ON A DAIRY FARM IN THE NEW YORK CEAP WATERSHED

2.1 Introduction

Agriculture in the US is responsible for 47% total phosphorus (P) and 52% total nitrogen (N) discharged into US streams (Allan 1995). As a result, agricultural producers face pressure to reduce or more efficiently manage nutrients, particularly animal wastes such as manure to minimize loss of contaminants such as P and N. This is particularly important in the New York City (NYC) source watersheds in the Catskill Mountains where local economic development can be curtailed when in reservoir P levels are above the New York State Department of Environmental Conservation (NYSDEC) standard of 20 μg L^{-1} (NYSDEC 1993). To reduce P levels in the NYC source watersheds, both point and non-point source controls have been installed beginning in the mid 1990's, and although in stream/reservoir P levels have been consistently declining, dissolved P concentration in runoff from intensively managed pasture and hayfields in the upper reaches of the watersheds are 10 to 30 times the NYSDEC standard (Hively *et al.* 2005). Nitrate (NO_3^--N) concentration in the NYC source watershed are in general 3 to 4 times below standard for drinking water of 10 mg L^{-1} (US Environmental Protection Agency 2003) but may pose a threat to water quality at much lower levels. Indeed, Effler and Bader (1998) documented NO_3^--N additions to the Cannonsville Reservoir well below EPA standards as problematic and the reservoir has shown a tendency to N limitation on algal production during mid-summer.

Although the overall concentrations of N and P generally decrease after installation of best management practices (BMPs) (Bishop *et al.* 2005; Brannan *et al.* 2000; Lee *et al.* 2000; Inamdar *et al.* 2001; Gitau *et al.* 2004), it is often unclear which BMPs are most effective, and there is a large range in efficiency of individual BMPs on overall water quality (Gitau *et al.* 2005). For instance, in the NYC source watersheds milkhouse buffer strips were only effective in reducing P levels for a five to ten year period following installation (Kim et al. 2006); exclusionary fencing reduced manure additions and hence the load of P deposited in the streams by cows (James *et al.* 2007), but depends on where and how it is installed; precision feeding resulted in less P excreted in manure (Maguire *et al.* 2005; Rotz *et al.* 2005; Toor *et al.* 2005), but it is unclear how this impacts water quality in the short term; barnyard improvements can reduce runoff losses, and are beneficial for animal health, but often fail to actually reduce P levels in runoff (Robillard and Walter 1984; Bishop *et al.* 2005).

One BMP that seems to be successful in reducing the N and P loads to streams and has been installed more than any other practice in the NYC source watershed is exclusionary fencing and cattle crossings (Line *et al.* 2000; Meals 2000; James *et al.* 2007). Bishop *et al.* (2005) speculated that the improvement in water quality on a dairy farm was partially due to stream crossings and exclusionary fencing that prevented direct cow access to the stream. Line *et al.* (2000) documented reductions of 76% in total P in a stream after fencing was installed in North Carolina. Fencing has been tested to limited extent in the Northeast US yet there are no conclusive reports in the literature relating to the effectiveness of these BMPs on water quality.

The objective of this research is to quantify the stream water quality impact of BMPs that exclude livestock from streams. Although most studies simply look at the downstream effect before and after installation of BMPs, we examine in detail the cause of the reduction. Two streams are compared, one that had exclusionary fencing and cattle crossing installed (treatment), and one stream that did not (control). Because there is evidence that dissolved oxygen (DO) and dissolved organic carbon (DOC) influence dissolved P and NO_3^--N levels in water we measure DOC and DO in all samples collected and include them in the statistical analysis. We also quantify relative effect of groundwater NO_3^--N and dissolved P levels on stream flow concentrations. The study was conducted a valley farm in the Catskill Mountains in central New York State from October 2003 to April 2006.

2.2 Material and Methods

2.2.1 Study Site

The study site is located the Cannonsville Reservoir CEAP watershed in the Catskill Mountains in central New York State on one of the many dairy farms. The farm is located along a lowland tributary of the West Branch of the Delaware River. The dairy farm has 19 ha of valley bottom land and 119 ha of uphill lands. Small creeks originate from springs, either on the hillslopes surrounding the farm, or on the farm itself. The creeks flow from north to south (Fig. 2.1). Springs on the hillslopes are formed at several locations where the steep hillslopes flatten and are active for the majority of the year except at times in the summer. The water from the spring, sampling site A1, in the northwest area of the site forms a creek (Creek A in Fig. 2.1) and then flows though the farm. Creek A is gaining by groundwater flow during most of the year but looses water for a period during the summer and fall and may become dry during extended rainless periods. In the southern area of the farm, regional groundwater intersects the surface and forms saturated areas around Creek B (Fig. 2.1), especially during the period when precipitation exceeds evapotranspiration (October to May). Creek B is solely fed by groundwater.

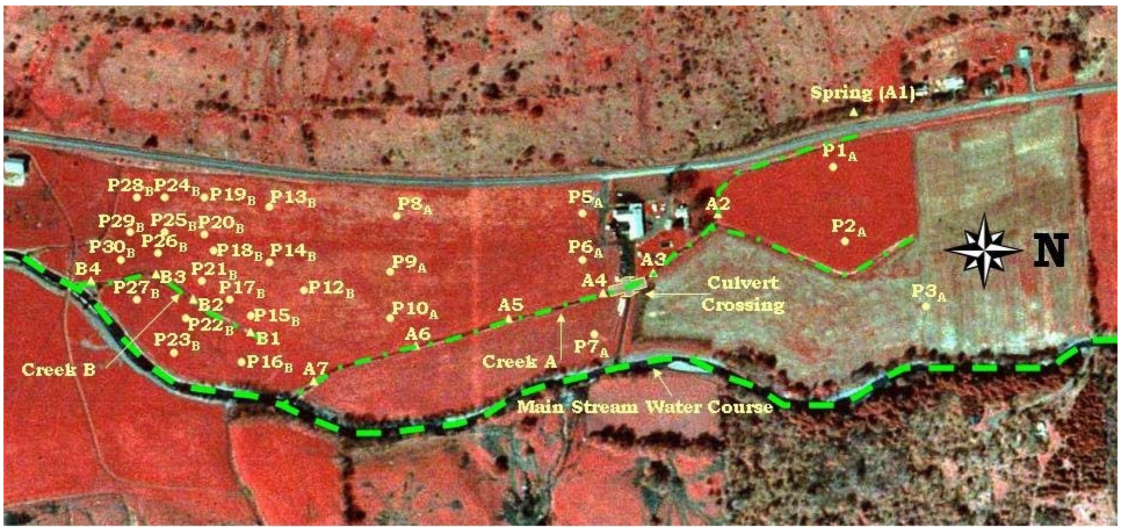

Figure 2.1 Study site showing the location of Creeks A and B, The culvert crossing BMP, the thirty piezometers. The groundwater table depth, measured with capacitance probes at each piezometer site was averaged for each Creek (the direction of the steady state groundwater flow was derived from the apparent equipotential lines).

Rainfall data was obtained from Northeast Regional Climate Center (NRCC) in Walton, NY approximately 9 km to the South-East of the field site. The annual average precipitation for the study site is 1,120 mm yr^{-1}, approximately one-third of which falls as winter snow (December to April) (National Climatic Data Center 2000). The climate of the Cannonsville Reservoir watershed is humid continental with an average temperature of about 8ºC, and the growing season extends from May to September.

In 2004, the farm had 60 adult dairy and beef cows and 36 heifers producing 833 Mg (ton) of manure per year that was spread mainly on the valley bottom lands during the winter, when eighty percent of the manure was applied (and mainly on the corn land). During the remainder of the year the herd is pastured, thus less manure is produced in the barnyard, but more is deposited in the pasture. Since September 1995, the farm has participated in the Watershed Agricultural Program (WAP). The WAP is an organization that is managed by the Watershed Agricultural Council and partly funded by the New York City Department of Environmental Protection (NYCDEP) and aids farmers with whole farms plans including BMP implementation. As part of this program a 5 m long culvert crossing was installed in Creek A during the third week of September 2005 so that the cattle could cross the stream without directly entering it. Exclusionary fencing was installed to delimit the 5 m width of the cattle path from the barnyard to the pasture and to prevent livestock free access to the stream. Before the culvert crossing was installed on Creek A, cattle and farm machinery entered the stream to cross. Creek B has no exclusionary fencing or culvert crossing allowing direct livestock access, and thus serves as a control with which the fenced Creek A may be compared.

2.2.2 Water Sampling

Stream water was sampled at eleven locations along the course of Creeks A and B (Fig. 2.1) (Flores-López *et al.* 2009). The 11 stream sampling locations were divided up as follows: one at the spring site, six along the Creek A, four along Creek B, (Fig. 2.1). A total of 655 stream flow samples were collected over the study for analysis.

The spring sampling site, A1, was located on the northwest hillslope (Fig. 2.1). Sampling site A2 was located 230 m downstream from A1 on Creek A (Fig. 2.1). Sampling sites A3 and A4 were located 330 and 350 m downstream from sampling site A1, and between them the cattle path crosses Creek A (Fig. 2.1). Stream water samples were collected from a sampling site directly upstream of the cattle crossing path (A3) and one directly downstream (A4). Sampling sites A5 and A6 were located 420 and 540 m downstream from A1 and sampling point A7 was 710 m downstream from A1 and directly before the confluence with the main stream course (Fig. 2.1).

Sites B1 to B4 were located in Creek B, which drains groundwater in a low lying area of the downstream field (Fig. 2.1). Sampling points B2, B3, and B4 were located along Creek B at 65, 130, and 200 m, respectively downstream from B1. Sampling site B4 was located directly upstream from the confluence with the main water course (Fig. 2.1).

Thirty subsurface piezometers were installed in the field site at different depths (0.3 to 1.5 m) (Fig. 2.1) and were used to extract groundwater samples to measure soluble reactive P (SRP), nitrate (NO_3^--N), dissolved organic carbon (DOC), and dissolved oxygen (DO) (Flores-López *et al.* 2009). A total of and 717 groundwater samples were collected for analysis. The piezometers and streams were always sampled at the same time. The groundwater samples were compared against the stream measurements during the analysis. The groundwater table depth measured with capacitance probes at each piezometer site was averaged for each Creek. To determine the direction of the steady state groundwater flow we used the apparent equipotential lines from the water table levels derived from the capacitance probe data.

2.2.3 Chemical Water Analysis

Stream water samples were collected at least bimonthly, although occasionally more frequently from October 2003 through April 2006. A volume of 100 ml of stream water flow was collected in pre-cleaned plastic bottles. Pre-cleaning entailed rinsing thoroughly with distilled water. Water samples were collected with no headspace and stored in coolers to prevent temperature increases during transport to the laboratory. Water chemistry analysis for stream water samples is discussed in detail in Flores-López *et al.* (2009), below we briefly outline the procedures.

Dissolved Oxygen (DO) concentration was measured directly in each sample bottle using a Traceable ® Digital Oxygen Meter (Fisher Scientific) within 3 to 4 hr of sampling. The instrument has a resolution of 0.1 mg L^{-1}. The probe was inserted into each bottle to obtain the DO concentration reading and avoiding interaction with ambient air. Before each use, the probe was rinsed with distilled water. Dissolved oxygen concentration readings were started in January 2005. Testing showed that there was no significant difference between DO measurements taken in the field and laboratory. After measuring the DO concentration, samples were filtered through 0.45 μm membrane filters using a vacuum pump filtering system. Filters were washed with 5 ml of distilled water before filtering.

Stream water samples were analyzed for SRP within 24 hours of sampling or were filtered and stored in a refrigerator until they could be analyzed. The filtered samples were analyzed using the OI Analytical FlowSystem 3000 Automated Ascorbic Acid Method for SRP with a detection limit of 0.001 mg L^{-1} following the instructions in the in-house manual for the operation (Method 4500-P G (Ortho-P) and Method 4500-Ph (Total P) In: Apha/Awwa/Wef 1999). SRP analyses began with the first sample set on October 1st, 2003.

Stream water samples were analyzed for NO_3^--N beginning in the spring of 2004. The spectrophotometric method and a Spectronic 501 instrument by Bausch & Lomb were used following the instructions in the in-house manual for the operation (Cataldo *et al.* 1974). NO_3^--N analyses were done for all samples except for those samples collected during winter where initial analysis indicated that NO_3^--N concentrations were below the detection limit (0.05 mg L^{-1}). These samples were excluded from the analysis. NO_3^--N analyses began on March 2004.

Dissolved Organic Carbon (DOC) analyses were conducted using the IO Analytical Model 1010 Total Organic Carbon Analyzer with a detection limit of 0.1 mg L^{-1} following the instructions in the operator manual (IO-Analytical 1997). Sample analyses for DOC started in January 2005.

2.2.4 Multivariate Analysis of Covariance Model

A multivariate analysis of covariance –ANCOVA– model (USEAP 1997; Bishop *et al.* 2005) using matched treatment (Creek A) and control (Creek B) data was used to determine the impact of the near stream BMPs in the treatment creek (Creek A). Variables collected in both the control creek and the treatment creek or in the respective drainage areas of both creeks included in-stream and groundwater SRP,

NO_3^--N, DO, and DOC concentrations, groundwater table height (*GWTD*), and season [growing (May - September) or non-growing (October - April)]. In-stream samples were collected at seven locations in the treatment creek (A1-A7) and four locations in the control creek (B1-B4) (Fig. 2.1). The locations of the sampling sites A1-A7 were aggregated into two classes, above or below the BMP (note that the culvert was installed on Creek A). Table 2.1 presents the descriptive statistics collected during the study. Since less that 200 m separates the treatment and control creeks rainfall *(RF)* was assumed to be evenly distributed between the two creeks and was incorporated as a variable in the analysis.

Table 2.1 Descriptive statistics by season for soluble reactive phosphorus (SRP), nitrate-N (NO_3^--N), dissolved organic carbon (DOC) and dissolved oxygen (DO) concentrations and groundwater table depth.

Season	Statistics	SRP	NO_3^--N	DOC	DO	Groundwater Table Depth
Creek A			mg L^{-1}			m
Growing Season	Mean	0.051	1.057	2.269	5.366	0.836
	Std. Deviation	0.06	0.89	1.66	1.81	0.22
	Maximum	0.35	2.31	9.10	9.20	1.23
	n	176	56	45	50	144
Non-Growing Season	Mean	0.034	1.020	1.542	5.780	0.692
	Std. Deviation	0.04	0.88	1.28	1.94	0.12
	Maximum	0.26	3.83	8.50	11.80	1.01
	n	23	40	31	26	19
Creek B						
Growing Season	Mean	0.047	0.941	1.600	4.775	0.578
	Std. Deviation	0.07	0.82	2.16	1.31	0.22
	Maximum	0.40	2.53	12.90	10.20	1.47
	n	108	36	34	36	85
Non-Growing Season	Mean	0.026	1.203	2.342	5.785	0.545
	Std. Deviation	0.03	0.80	3.39	1.91	0.28
	Maximum	0.18	2.26	20.40	10.40	1.31
	n	97	20	59	54	66
Overall	Mean	0.041	1.039	1.885	5.538	0.695
	Std. Deviation	0.05	0.86	2.19	1.85	0.24

We construct three ANCOVA models to stepwise explain the effect of the near stream BMPs. First, we test whether there was a significant difference between the pre- and post-BMP time periods. If there is a significant difference between the pre- and post-BMP periods the second ANCOVA tests for a significant difference between Creek A (treatment) and Creek B (control) in the post-BMP period by controlling for the variance associated with measurements in Creek B and groundwater. The third ANCOVA model tests for a significant difference between location on Creek A above and below the BMP during the post-BMP period. Variables were natural log transformed to remedy increasing error variance and non-normality of residuals. Least squared means were used to estimate BMP effects in all models. For each seasonal model the complete model with all main and interaction effects was fit and non-significant terms (at α=0.05) subsequently dropped (See Table 2.2 for significant terms).The complete ANCOVA model (excluding interaction terms) is (for SRP as an example):

$$Ln(SRP_A)= a + b(Period + c(BMP) + d(Location) + e(lnSRP_B) + f(lnDO_{A,B}) + g(lnDOC_{A,B}) + h(lnRF)+ i(lnGWSRP_{A,B}) + j(lnGWDO_{A,B}) + k(lnGWDOC_{A,B}) + l(lnGWTD_{A,B})+ \varepsilon_i \tag{2.1}$$

where *a* is the intercept, *b* - *l* are the slopes of the individual variables, *Period* is the BMP time period (0 for pre-BMP, and 1 for post-BMP), *BMP* indicates the presence of the BMP [0 for no BMP present (Creek B), and 1 for BMP present (Creek A)], *Location* is an indicator variable in Creek A (0 for sampling locations above the culvert, and 1 for sampling locations below the culvert), ε_i is the model error, and all others as above. Subscripts indicate which creek or contributing area the variable was measured in.

Three seasonal ANCOVA models are used to analyze the effectiveness of the near stream BMPs. First we determine if there is a significant difference in stream SRP or NO_3^--N concentrations between pre and post BMP time periods using the following ANCOVA (for SRP as an example):

$$Ln(SRP_A) = a + b(Period) + c(lnSRP_B) + d(lnRF) + e(lnGWSRP_A) + f(lnGWTD_A) + \varepsilon_i \tag{2.2}$$

For the seasonal model differences between the pre- vs. post-BMP time period were tested using a one sided *t-test* on the *b* coefficient at the α=0.05 level. Next we test the lumped impact of the culvert on stream SRP or NO_3^--N levels during the post BMP period using (for SRP as an example):

$$Ln(SRP_A) = a + b(BMP) + c(Period) + d(lnSRP_B) + e(lnGWSRP_A) + f(lnRF) + g(BMP*Period) + \varepsilon_i \tag{2.3}$$

where *a* is the intercept, *b* – *g* are the slopes of the individual variables, *BMP*Period* is an interaction term that indicates the presence of the BMP during the post-BMP period, and all others as above. Differences between Creek A and B with and without the BMP during the post-BMP time period were tested using a one sided *t-test* on the *g* coefficient at the α=0.05 level. Finally, we test the direct impact of the culvert in Creek A during the post-BMP period using (for SRP as an example):

$$Ln(SRP_A) = a + b(Period) + c(Location) + d(BMP) + e(lnSRP_B) + f(lnGWSRP_A) + g(lnGWTD_A) + h(Period*BMP*Location) + \varepsilon_i \tag{2.4}$$

where *Period*BMP*Location* is an interaction term that tests the effect of the location in Creek A during the post-BMP period. Differences between sampling locations in Creek A above and below the BMP location during the post-BMP period were tested using a one sided *t-test* on the *h* coefficient at the α=0.05 level.

Homogeneity of the regression slopes was tested by comparing the interaction effects of the *Period, BMP*, and *Location* variables in ANCOVA models against a *p-value* of 0.05. Table 2.2 shows that there were significant interaction effects for the ANCOVA model testing the effect of *BMP* in Equation 2.3 and *Location* (Equation 2.4, Table 2.2). Because the slopes for the *Period*, *BMP,* and *Location* variables are not the same we use a model that estimates slopes for all *Period*, *BMP,* or *Locations* variables separately. Using the 'estimate' statement in SAS (SAS Institute 2008) we constructed statements to test the effect of *Period, BMP,* and *Location* for both the pre- and post-BMP periods. This test allowed us to estimate the impact of the BMP on SRP levels in Creek A while controlling for other variables in the ANCOVA (Table 2.3).

Identical analysis was performed for in-stream NO_3^--N concentrations, but no significant *Period, BMP,* or *Location* effects were detected, indicating that the fencing did not affect the NO_3^--N concentration in the stream. Therefore our analysis focuses on mainly on SRP concentrations but some discussion of NO_3^--N is included.

2.3 Results

2.3.1 Descriptive Statistics

The overall average SRP concentrations measured in Creek A and Creek B were 0.043 and 0.037 mg L^{-1}, respectively, similar to groundwater for SRP levels (Flores-López *et al.* 2009). Average NO_3^--N concentrations were 1.042 and 1.035 mg L^{-1} for Creeks A and B, respectively (Table 2.1), but temporal variability was observed. The average DOC concentration in Creek B was significantly higher (2.07 mg L^{-1}) than the concentration in Creek A (1.76 mg L^{-1}). The average DO concentrations were not significantly different, 5.63 and 5.38 mg L^{-1} for Creek A and Creek B, respectively. The seasonal variability of all four chemicals (Table 2.1) indicates that the lowest average stream SRP concentration was observed during the non-growing season for both creeks. Stream NO_3^--N concentrations were highest during the growing season for Creek A, and non-growing season for Creek B. The highest DOC concentrations for Creek A were observed during the growing season and for Creek B during the non-growing season. Higher stream DO concentrations were observed during the non-growing season in both creeks (Table 2.1).

In general, SRP concentrations in Creek A were higher than in Creek B for the pre-BMP period (before crossing was installed). In Creek A, before the culvert was installed the highest mean concentration of 0.11 mg L^{-1} was measured during the growing season, and in Creek B the highest levels observed were (0.04 mg L^{-1}). In the pre-BMP period the lowest mean concentrations were observed during the non-growing season for both Creeks A and B (both 0.03 mg L^{-1}). The mean SRP level for Creek A during the pre-BMP period was 0.06 mg L^{-1}, nearly twice the concentration in Creek B (0.03 mg L^{-1}). After the crossing was installed (post-BMP period), the SRP concentrations in Creek A declined by 30% (average of 0.04 mg L^{-1}), while conversely SRP levels in Creek B increased 41% (average of 0.05 mg L^{-1}) compared to the pre-BMP period (Table 2.3). The increase in SRP concentrations in Creek B post-BMP indicates that exogenous variables, such as precipitation or temperature might actually have reduced the perceived effectiveness of the crossing in Creek A.

Precipitation (Fig. 2.2) in 2004 and 2005 were 23 and 6%, respectively higher than the long term annual average precipitation (1,120 mm yr^{-1} based on National Climatic Data Center 2000). The partial years sampled during the study, 2003 and 2006, had approximately normal precipitation levels. A significant difference was observed between the 2004 and 2005 growing season where 829 mm of precipitation were measured from May to September of 2004 compared to 311 mm during the same months in 2005. The average precipitation for the growing season over the study period was 596 mm.

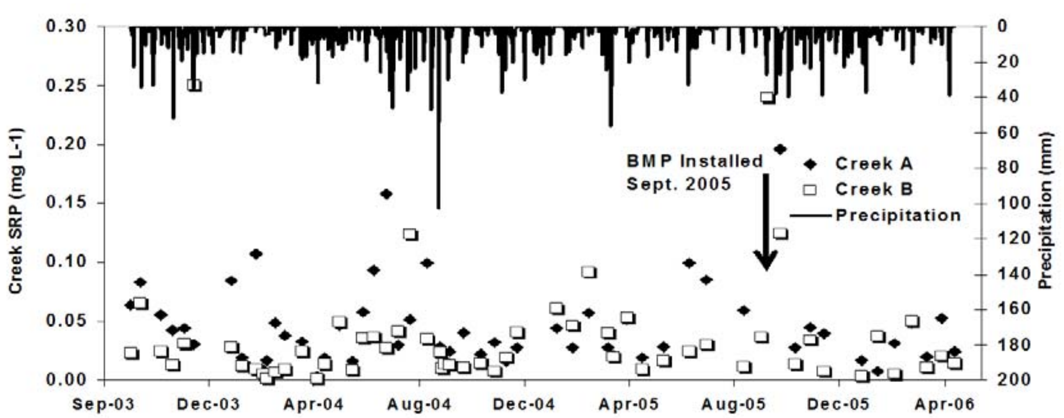

Figure 2.2 Control (Creek B) and treatment (Creek A) creek soluble reactive P (SRP) concentrations, and precipitation depths during the pre- and post-BMP periods.

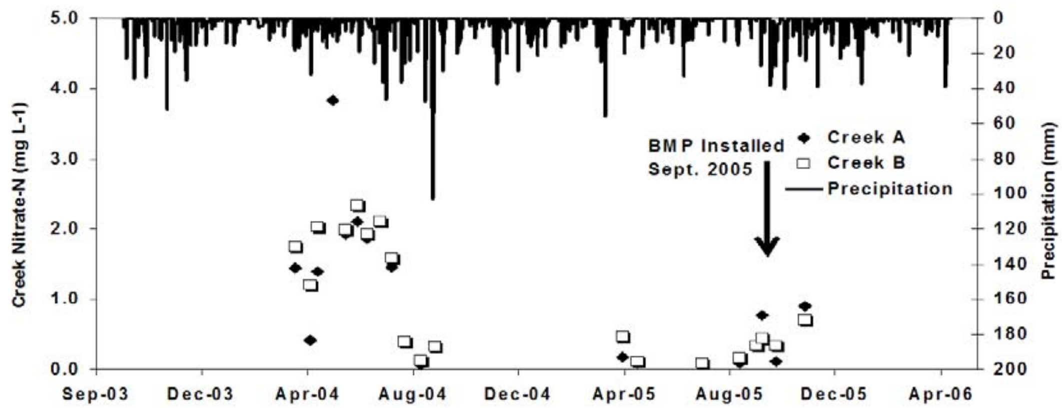

Figure 2.3 Control (Creek B) and treatment (Creek A) creek nitrate-N (NO_3^--N) concentrations, and precipitation depths during the pre- and post-BMP periods.

Figures 2.2 and 2.3 show time series of the SRP and NO_3^--N concentrations in Creeks A and B, respectively over the study period. The NO_3^--N concentrations in Creek A and Creek B (Fig. 2.3) during the pre- and post-BMP period were well below the 10 mg L^{-1} standard for drinking water. Note in Fig. 2.2 that elevated SRP concentrations occur in both the pre- and post-BMP periods. However, it is also apparent that the concentrations in Creek B are elevated during the post-BMP period (Fig. 2.2). Simply looking at the time series, one might be tempted to assume that the BMP was effective since Creek A concentrations were significantly lower during the post-BMP period than during the pre-BMP period (paired t-test at α=0.05). Creek B concentrations were, on average significantly lower during the post-BMP period as well. Neglecting the two high SRP concentrations in Creek B during the post-BMP period, Creek B concentrations appeared to have fallen as well. However, it is not clear from Fig. 2.2 what the source of the SRP reduction is, as other exogenous variables such as climatic variability could have influenced the Creek A concentrations. Thus, use of the matched concentration ANCOVA should correct for imbalances in precipitation, groundwater and other factors between the pre- and post-BMP periods (Bishop *et al.* 2005) and result in detectable BMP effects if significant. Fig. 2.4 shows a relatively strong relationship between the log of the SRP concentrations between Creek A and Creek B during both the pre- and post-BMP time periods, indicating that incorporating parameters controlling Creek B SRP concentrations should help improve model results.

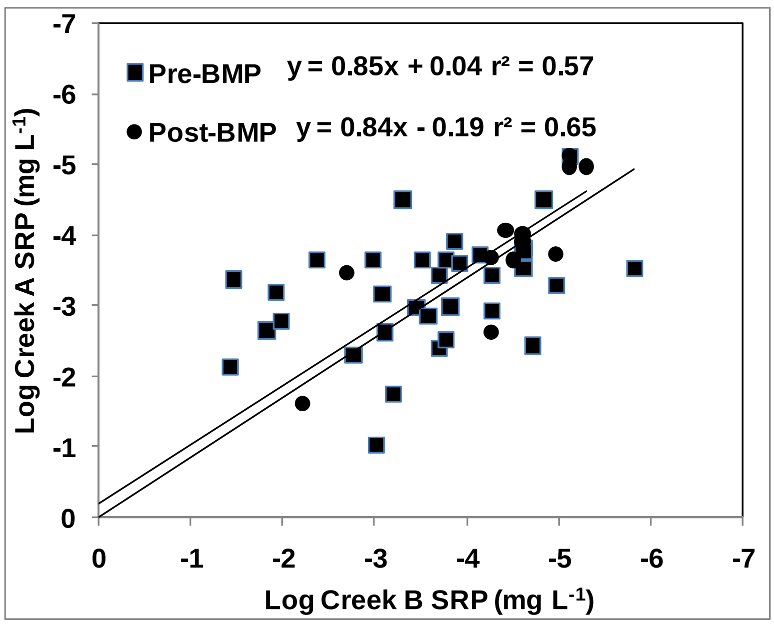

Figure 2.4 Log matched concentrations (averaged by creek) for Creeks A and B over the pre- and post-BMP period.

2.3.2 Multivariate Analysis of Covariance

Table 2.2 presents the results of the three ANCOVA analyses by season and for the whole year. First, we test whether there was a significant difference between the pre- and post-BMP time periods (Equation 2.2). The second ANCOVA tests for a significant difference between Creek A (treatment) and Creek B (control) in the post-BMP period by controlling for the variance associated with measurements in Creek B and groundwater (Equation 2.3). The third ANCOVA model tests for a significant difference between location on Creek A above and below the BMP during the post-BMP period (Equation 2.4).

Table 2.2 Analysis of Covariance (ANCOVA) for test of significant differences in stream soluble reactive phosphorus (SRP) concentrations for Creek A.

Parameter $\ln(SRP_A)$	Growing Season		Non-Growing Season		Full Year	
	ANCOVA Test for Concentrations between Pre and Post BMP Periods (Equation 2.2)					
	p-value	SumSq	*p-value*	SumSq	*p-value*	SumSq
Intercept	0.048	-	0.029	-	0.033	-
$\ln(GWSRP_A)$	<0.001	77.56	NS	-	0.006	147.61
$\ln(SRP_B)$	0.005	64.43	0.027	47.43	0.009	102.12
$\ln(GWTD_A)$	0.039	34.32	0.046	30.04	NS	-
ln(RF)	0.009	19.81	NS	-	NS	-
Period	**0.010**	**6.22**	**NS**	**-**	**0.004**	**12.07**
Adj. R^2 (*p-value*)	0.87 (<0.001)		0.81 (0.164)		0.83(<0.001)	
	ANCOVA Test of BMP Effectiveness in the Post BMP Period (Equation 2.3)					
Intercept	NS	-	0.050	-	0.038	-
$\ln(GWSRP_A)$	<0.001	156.64	NS	-	0.007	269.06
$\ln(SRP_B)$	<0.001	109.32	<0.001	162.23	<0.001	212.23
ln(RF)	<0.001	143.27	NS	-	0.018	200.29
BMP	**0.015**	**12.56**	**NS**	**-**	**<0.001**	**34.51**
Period†	**NS**	**-**	**NS**	**-**	**NS**	**-**
BMP*Period	**0.043**	**5.54**	**NS**	**-**	**0.048**	**4.43**
Adj. R^2 (*p-value*)	0.72 (<0.001)		0.46 (0.125)		0.56 (<0.001)	
	ANCOVA Test of Location in Creek A (above or below the BMP) (Equation 2.4)					
Intercept	NS	-	0.003	-	0.014	-
$\ln(GWSRP_A)$	<0.001	46.12	0.036	122.32	<0.001	271.35
$\ln(SRP_B)$	0.021	9.74	NS	-	0.019	11.50
$\ln(GWTD_A)$	<0.001	12.96	0.050	152.83	<0.001	168.94
Period†	**NS**	**-**	**NS**	**-**	**NS**	**-**
BMP†	**NS**	**-**	**NS**	**-**	**NS**	
Location	**<0.001**	**27.28**	**NS**	**-**	**<0.001**	**36.82**
Period*BMP*Location	**<0.001**	**3.14**	**NS**	**-**	**0.004**	**3.99**
Adj. R^2 (*p-value*)	0.79 (<0.001)		0.54 (0.026)		0.61(0.016)	

†*Period* and *BMP* included in model due to significant interaction effect

The ANCOVA model to test for a detectable difference in the log of the SRP concentrations between the pre- and post-BMP time periods in Creek A (Equation 2.2, Table 2.2) resulted in high predictive accuracy for both the growing season and whole year models (adjusted $R^2 = 0.87$ and 0.83, respectively, Table 2.2), and significant overall effects. The non-growing season model was not significant at $\alpha=0.05$, yet still had good predictive power (adjusted $R^2 = 0.81$). The log of Creek A SRP levels during the growing season were highly covariate with the log of Creek B SRP, the log of groundwater SRP levels, and the log of groundwater table depth in the area contributing to Creek A, as indicated by the highly significant *p-values* and large sums of squares (Table 2.2). More importantly, the model was able to detect a significant difference in the log of the Creek A SRP levels between the pre- and post-BMP periods for both the growing season and whole year models (e.g., one sided *t-test* of the *Period* variable, Table 2.2). The reductions in the pre- and post-BMP period SRP concentrations estimated by the model were 0.008 mg L^{-1} during the growing season and 0.005 mg L^{-1} for the whole year (Table 2.3).

To test the effectiveness of the BMP installed on Creek A we constructed a second model (Equation 2.3, Table 2.2). This overall model was highly significant for the growing season and whole year periods, but not for the non-growing season period (Table 2.2). Similar to the model to test the pre- and post-BMP time periods (Equation 2.2), the log of the groundwater SRP levels in the areas contributing to Creek A and the log of the SRP concentrations in Creek B were highly significant covariates. The test of the effectiveness of the BMP was assessed only during the post-BMP period (e.g., the *BMP*Period* interaction in Equation 2.3 and Table 2.2). The ANCOVA model detected a significant *BMP*Period* interaction in Creek A for the growing season and whole year model (Table 2.2). Table 2.3 shows the magnitude of the reduction attributable to the BMP to be 0.007 and 0.009 mg L^{-1} SRP for the growing season and whole year models, respectively.

Table 2.3 Analysis of the *Period* (Equation 2.2), *BMP*Period* interaction (Equation 2.3) and *Period*BMP*Location* interaction (Equation 2.4) for Creek A showing the estimated difference (in mg L^{-1}) in SRP concentrations. Note that the estimates were back transformed to non log units for display in the table, *p-values* are from log transformed tests.

Parameter: *lnSRP*	Growing Season		Non-Growing Season		Full Year	
	Estimate	*p-value*	Estimate	*p-value*	Estimate	*p-value*
Pre-BMP vs. Post-BMP (Equation 2.2)	0.0080	0.004	0.0001	0.432	0.0053	0.032
Post-BMP with BMP vs. Post-BMP No BMP (Equation 2.3)	0.0073	0.032	0.0003	0.103	0.0085	0.041
Pre-BMP Period (Equation 2.4)						
Above BMP vs. Below BMP	0..0059	<0.001	0.0042	0.076	0.0085	0.003
Post-BMP Period (Equation 2.4)						
Above BMP vs. Below BMP	0.0004	0.107	0.0001	0.191	0.0005	0.137

To investigate the impact of the BMP in Creek A we constructed a final test indented to ensure that other factors were not unduly influencing the ‘BMP’ effect (Equation 2.4 Table 2.2). As with previous models the log of the Creek A SRP concentration was covariate with the log of the Creek B SRP levels, the log of the groundwater SRP levels and groundwater table height in the area contributing to Creek A, (Table 2.2) for both the growing season and whole year models. Interestingly, the non-growing season model was significant at α=0.05 (Table 2.2), but there was no *BMP* effect, only the log of the groundwater SRP and the log of the groundwater table height in the Creek A area were significant predictors of the log of the SRP concentrations in Creek A (Table 2.2), thus since our focus is on BMP effects we do not explore the impact of these variable on the SRP levels in Creek A. The three way interaction term in the model, *BMP*Period*Location,* results in a test of the stream sampling location for each of the pre- and post-BMP periods (e.g., Pre-BMP period below the BMP location vs. Pre-BMP period above the BMP location and Post-BMP period below the BMP location vs. Post-BMP above the BMP location). The results of these tests are shown in Table 2.3, where it is estimated that, during the pre-BMP period there was a significant difference between locations in Creek A. Specifically, sampling points located above the BMP location (Fig. 2.1) had SRP concentrations 0.006 and 0.008 mg L^{-1} lower than locations below the BMP for the growing season and whole year models, respectively (Table 2.3). There was no significant difference in the SRP concentrations during the non-growing season. During the post-BMP period there was no significant difference between the sampling locations above and below the BMP location for any of the models (Table 2.3). Figure 2.5 shows the SRP concentrations by sampling site in both Creeks A and B for the pre- and post-BMP periods. Estimated reductions during the post-BMP period resulting from the ANCOVA models for Equation 2.3 and 2.4 both indicate that the BMP resulted in a SRP reduction of approximately 26% for the yearly model and 33% for the growing season model.

2.4 Discussion

While culverts and exclusionary fencing are widespread BMP practices to reduce N and P pollution of water bodies in agricultural areas, there is little information regarding their impact on water quality. Intuitively, preventing direct livestock access from water bodies will reduce the chance of fecal deposits and the disturbance of P laden stream sediments. However, environmental noise can often obscure the effects of BMPs in agricultural systems making detection of their impact difficult. For instance, while N reductions were not attributable to BMPs installed on Creek A, it appears from Fig. 2.3 that NO_3^--N concentrations in both Creek A and B were lower during the post-BMP period. This difference might be due to BMP (yet not detectable) or from climatic variation, and become significant over time, thus additional analysis is warranted.

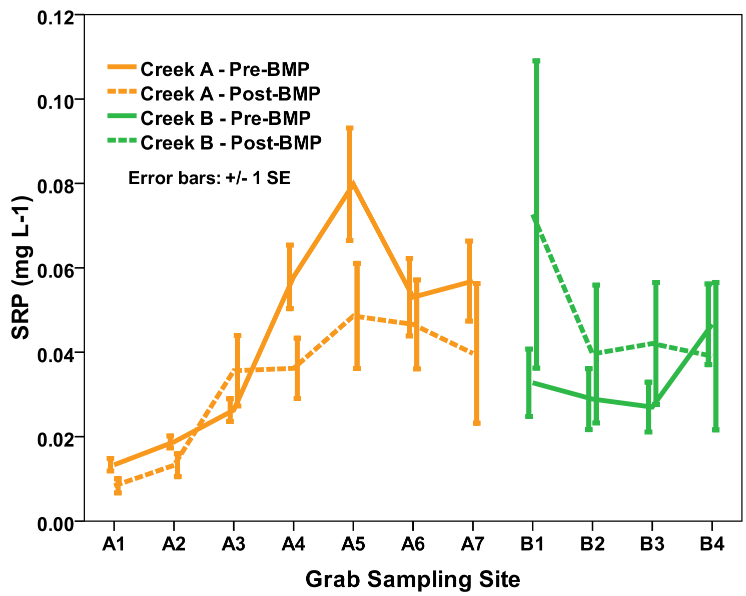

Figure 2.5. Mean SRP stream concentrations by sampling sites for Creek A and Creek B. Stream sampling site locations are shown in Figure 2.1. Note that the BMP was installed between sampling sites A3 and A4 in Creek A. Sampling sites in Creek A were lumped into above and below the BMP site for analysis.

Analysis of SRP results presented in Table 2.3 indicate that during the pre-BMP period there was a significant (at α=0.05) difference between SRP concentrations from Creek A sampling locations located above and below where cattle had direct stream access (i.e. the in-stream cattle crossing) for the growing season. The full year model was significant as well, but slightly less so than the growing season model (*p-value* =

0.003, Table 2.3). During the non-growing season there was no significant difference between sampling locations, somewhat intuitive, as cattle are not pastured during the winter and thus had no access to the stream. Estimates of the contrast differences likewise show a large difference in the SRP concentrations in Creek A above and below the crossing in the pre-BMP period (Table 2.3). In the Pre-BMP period, during the growing season the SRP concentrations were, on average 0.006 mg L^{-1} lower at sampling locations above the crossing (Table 2.3 Fig. 2.5). Expected reductions in the SRP levels during the non growing season were lower (0.004) and less significant (*p-value*= 0.076) (Table 2.3).

During the post-BMP period both the seasonal and full year models (Equation 2.4 and Table 2.3) indicate that there is no significant difference between sampling locations above and below the BMP installation (Table 2.3). While the estimated differences remain negative (i.e., estimated reductions in SRP concentrations between locations above and below the BMP were 0.0001 to 0.0005 mg L^{-1}), they are not significant at the α=0.05 level. The marginal significance of the growing season model (*p-value* = 0.107) might simply be a result of limited sampling duration during the post-BMP period. However, it is somewhat remarkable that the estimated differences in SRP concentrations equalized across sampling locations so quickly following installation of the BMP. Table 2.4 presents the SRP concentrations during the pre- and post-BMP periods for both Creek A and B at all sampling points, and clearly shows that, while SRP concentrations declined significantly below the BMP location (A4-A7) they were still somewhat higher than the SRP concentrations above the BMP location (A1-A3). We speculate that a longer sampling duration would have further reduced the differences between sampling locations along Creek A.

Table 2.4 Average concentrations by sampling sites for the pre-BMP and post-BMP scenarios in Creek A and Creek B.

Sampling Site	Pre-BMP Mean (± SE) (mg L^{-1})	n	Post-BMP Mean (± SE) (mg L^{-1})	n	Difference Between Scenarios (%)
Above BMP					
A1	0.013 (±0.002)	32	0.008 (±0.002)	8	-38
A2	0.019 (±0.001)	40	0.013 (±0.003)	9	-32
A3	0.026 (±0.003)	41	0.036 (±0.008)	8	38
Below BMP					
A4	0.058 (±0.008)	43	0.036 (±0.007)	10	-38
A5	0.080 (±0.013)	41	0.049 (±0.012)	10	-39
A6	0.053 (±0.009)	41	0.047 (±0.011)	10	-11
A7	0.057 (±0.009)	42	0.040 (±0.017)	11	-30
Creek B (No BMP)					
B1	0.033 (±0.008)	38	0.073 (±0.036)	11	121
B2	0.029 (±0.007)	39	0.040 (±0.016)	12	38
B3	0.027 (±0.006)	43	0.042 (±0.014)	12	56
B4	0.047 (±0.010)	38	0.039 (±0.017)	12	-17

The majority of the water in alluvial valley streams in the Catskill Mountains originates from hillsides and flows both overland, from the runoff source areas, and subsurface to the creeks. During the period of the year when precipitation exceeds evapotranspiration, runoff is generally the largest input to the stream from saturated areas. During the remainder of the year subsurface and return flows are the major sources of creek water. Thus, both surface and groundwater flows are sources of SRP in the stream. From a water quality standpoint agricultural activity can have a large impact on alluvial stream water quality. In this study the SRP concentration measured at the spring sampling site (A1 in Fig. 2.1) was 0.011 mg L^{-1} so Creek A SRP levels are initially controlled by the SRP concentrations at the spring site (A1) (Fig. 2.5). This is corroborated by the similar SRP levels measured at site A2 (0.016 mg L^{-1} of SRP) directly downstream from site A1, where little agricultural activity takes place. Further downstream (and prior to BMP installation) the concentration is influenced by P inputs from manure applications to fields (Kleinman *et al.* 2007), non-field areas (e.g. barnyard and cattle crossing path) (Hively *et al.* 2005), and the P concentration in streambed sediment (McDowell *et al.* 2001; Evans *et al.* 2004; van der Perk *et al.* 2007). Re-entrainment of P rich sediments in streams is speculated to be a large P source in the Cannonsville Reservoir watershed where livestock often graze freely and have access to streams (James *et al.* 2007). In the study site the dominant source areas for SRP are located in the regions downstream of the spring site (A1), the non-field areas of the cattle crossing, or, in this case from subsurface flow generated in the agricultural areas surrounding the stream, or directly from the stream channel itself. The concentration in the stream is generally higher than in the groundwater, indicating that surface sources, such as manure application, or the stream sediments and livestock are contributing to the increased stream SRP concentration, particularly during the summer, when groundwater contributions are limited.

Conversely, NO_3^--N, which is very soluble and does not become fixed on clays or organic matter and is easily transported with water, was measured at higher concentration in the groundwater (average of 2.2 ±0.2 mg L^{-1}) (Flores-López *et al.* 2009) than in the streams (average of 1.04 ±0.07 mg L^{-1}). That the NO_3^--N concentrations measured in the stream are substantially lower than those measured in the groundwater indicates that N in groundwater may be undergoing denitrification in the carbon rich, saturated, near stream areas, thus reducing the ultimate input to the stream. The increased DO and DOC levels from manure applications in coincidence with saturated areas near stream increase the microbial activity and thus the denitrification. Indeed, several researchers have noted the importance of DO and DOC levels in N and P dynamics (Flores-Lopez *et al.* 2009; Boyer *et al.* 1997; Schilling and Jacobson 2008). These effects might explain why there was no detectable change in NO_3^--N concentrations following BMP installation.

Flores-López *et al*. (2009) showed that groundwater had an impact on in stream concentrations of SRP. The average SRP groundwater concentration (0.041 mg L^{-1}) in the piezometers was slightly lower, but not statistically different (p-*value* = 0.612, n = 1198) from the in-stream concentration (0.043 mg L^{-1}) in Creek A and Creek B over 3 yrs of sampling. The groundwater SRP distribution depends not only on agricultural practices, but also on factors such as depth to the groundwater table (Flores-Lopez *et al.* 2009; Weiler and McDonnell 2006), occurrence of subsurface riparian flow (Schilling *et al.* 2007; Schilling and Jacobson 2008) or exfiltrated water in low lying areas or near the stream channel (Scott and Weiler 2001). Creek B in Fig. 2.5 appears to be influenced more by these factors than Creek A, which is more heavily dominated by agricultural activity, particularly sites A3-A7. For instance piezometers P6, P7, and P10, located in the contributing area for Creek A sites (A4-A7) there were no significant differences in SRP concentrations during the pre- and post-BMP periods. However, at stream sites (A4-A7 (Fig. 2.1), the in-stream SRP concentration for the post-BMP period was significantly lower (0.043 mg L^{-1}) than the in-stream SRP concentration for the pre-BMP period (Table 2.4) (0.062 mg L^{-1}) (p-*value* = 0.017, n = 208). The measurement of the groundwater SRP levels was an important parameter to consider in the analysis of the BMP effect.

There are two ways that the installation of the cattle crossing might have reduced the SRP concentration in the stream. Probably the most significant impact that BMPs such as cattle crossings have is that they prevent direct access of the cattle in the stream channel, and thus prevent the high P sediment in the stream bed from becoming entrained in the water column. Excluding cattle from the stream also prevents direct fecal inputs to the water bodies. Previous studies have shown that stream crossings and cattle paths that allow direct access to stream channels are a large source of P in streams (Bishop *et al.* 2005; Hively *et al.* 2005). Hively *et al.* (2005) found that hydrologically active non-field areas, which oftentimes cover a small spatial extent but produce high P concentrations (e.g. cow paths and barnyards), can contribute substantially to soluble P loading in streams. Indeed, prior to the installation of the culvert, SRP levels were excessively high at sampling sites directly adjacent to the crossing. The measured decline in SRP concentrations at sampling points downstream of the culvert crossing indicates that these structures considerably lower SRP contributions to the stream. Interestingly, in Creek B higher SRP concentration were measured for the post-BMP period. An average increase of 41% in SRP concentrations were observed at the four sampling sites in Creek B during the post-BMP period (B1-B4 in Fig. 2.1). This gives some perspective to the reduction in SRP levels in Creek A, in that controlling for environmental variability in the ANCOVA, the estimated reduction due to the BMP in Creek A are all that much more significant.

Finally, the fact that low SRP concentrations were observed in stream water samples implies that this valley bottom farm is not as large a pollutant source as many of the upland farms that have been monitored in the upland areas of the Catskills. Although high SRP concentrations were observed from samples taken in the saturated areas adjacent to Creek B, they were not as high as the SRP concentrations reported by Hively *et al.* (2005) and Kim *et al.* (2006) in nearby upland farms again indicating limited contribution of the alluvial areas, at least on this farm.

2.5 Conclusions

We collected three years of ground and surface water samples to quantify the impact of groundwater and near stream BMPs that exclude livestock from streams on SRP and NO_3^--N surface water concentrations by fencing and improved cattle crossings on a valley dairy farm in the Catskill Mountains of New York State.

A multivariate analysis of covariance incorporating ground and surface water measurements from a control and treatment creek was developed to determine the impact of near stream BMPs (fencing and cattle crossing) on in-stream SRP concentrations. The results of the analysis indicate that incorporation of these exogenous variables into the model increased the sensitivity and capability of the mode to detect BMP effects. The ANCOVA model showed that the installation of the BMPs resulted in a 26% reduction in Creek A SRP concentrations on a yearly basis and nearly 33% for the growing season. There was no detectable effect of the BMP during the non-growing season, as cattle are not pastured and thus never had direct stream access in the pre- or post-BMP period.

The temporal dynamics of processes governing P levels in streams indicate that many factors are involved. The fact that low SRP concentrations were observed in stream samples, irrespective of BMP installation, implies that the valley bottom farms are not contributing as much as many of the upland farms that have been monitored in the West Branch of the Delaware river watershed, although high SRP concentrations were observed in groundwater from saturated areas adjacent to Creek B. These results indicate that near-stream and in-channel processes should be considered when assessing the impact of agricultural activities on water quality..

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CHAPTER 3

SPATIAL VARIABILITY OF GROUNDWATER SOLUBLE PHOSPHOROUS ON AN ALLUVIAL VALLEY-FILL AQUIFER AND CONNECTION TO STREAM WATER QUALITY IN THE CATSKILL MOUNTAINS

3.1 Introduction

Agricultural activities can contribute residues of chemicals (i.e. applied organic and inorganic fertilizers, pesticides, and other chemicals field applications) to water bodies (Puckett, 1995; Sharpley *et al.*, 2001; Domagalski *et al.*, 2008). In humid regions, a significant portion of pollutant transport occurs under base flow conditions (Domagalski *et al.*, 2008; Stedinger *et al.*, 1993). Therefore, water bodies are affected by nutrient enrichment of groundwater systems (Spalding and Exner, 1993). In the Catskills Mountains of New York State, which supplies drinking water to New York City, the alluvial valley-fill aquifers provide the source of the base flow to most streams in the region. These valley bottom lands are utilized for intensive agricultural production, and have been identified as a contributor of nonpoint source soluble reactive phosphorus (SRP) to surface waters (Brown *et al.*, 1989; Hively *et al.*, 2005).

Agricultural nonpoint source pollution has prompted the adoption of best management practices (BMPs) (e.g. Easton *et al.*, 2008). While there have been many studies focusing on BMPs for controlling surface derived nutrient losses to water bodies [e.g., drainage ditch short circuiting (Kleinman *et al.*, 2007), vegetative filter strips (Murray, 2001; Kim *et al.*, 2006), and other BMPs' types (Brannan *et al.*, 2000; Lee *et al.*, 2000; Inamdar *et al.*, 2001; Gitau *et al.*, 2004; Bishop *et al.*, 2005)], limited research in alluvial valley areas of the Catskill/Delaware watershed has been conducted on the role of subsurface flow path derived P.

Several BMPs have been postulated that attempt to control groundwater quality including nutrient management (e.g., the amount of applied P through manure applications at watershed scale) and riparian buffer and stream exclusion (Sharpley *et al.,* 2001; Lee *et al.,* 2004; James *et al.*, 2007). Riparian buffer BMPs can potentially reduce nutrient loadings to surface and ground waters (Davis *et al.*, 2007). The effectiveness of riparian areas to decrease nutrients depends on the extent and type of vegetation, topography, and hydrology (Castelle *et al.*, 1994; Haycock and Pinay, 1993; Wigington *et al.*, 2003). Typical riparian buffer widths in the USA and Canada range from less than 10 m to more than 30 m (Lee *et al.*, 2004), but effective ranges have been reported from 3 - 200 m (Castelle *et al.*, 1994). However, data for riparian buffers are particularly imprecise for effective reduction in nonpoint source pollutants such as nutrients (USEPA, 2005; Wenger, 1999). Most of the riparian studies have focused on nitrate reductions (USACE, 1991; Staver and Brinsfield, 2001; Davis *et al.*, 2007), and only few have looked at SRP reductions. Groundwater SRP concentrations reported for crop fields in central New York State ranged from less than 0.02 to 0.08 mg L^{-1}, and results showed that SRP concentrations tended to be greater in imperfectly drained crop fields and in riparian areas (Young and Briggs, 2008). Given the extensive acreage of riparian BMPs for reducing nutrient movement from agricultural fields into streams, information on subsurface P dynamics in riparian areas is needed for improved understanding of their role in agricultural nonpoint source pollution (USACE, 1991; Lowrance *et al.*, 1997; Young and Briggs, 2008).

The specific objectives of this research were (i) to identify groundwater areas on a farm located in the valley alluvial soils of the Catskill Mountains that have the potential of contributing high SRP concentrations to streams, and (ii) to elucidate the effects that BMPs such as stream buffers and riparian areas have in controlling the stream base flow SRP concentrations.

The study was conducted from June 2004 through April 2006 on an alluvial valley plain under intense farming in the Catskill Mountains of New York State, upstream of the Cannonsville Reservoir which supplies drinking water to New York City.

3.2 Material and Methods

3.2.1 Study Site

The study site is located on a valley bottom dairy farm in the Cannonsville Reservoir watershed (1165 km^2) with a physiography characterized by narrow valleys with steep walls and flat valley bottoms (USDA NRCS, 2006). The 19 ha study site is located along of a tributary of the West Branch of the Delaware River (Flores-López *et al.*, 2009a). The depth to the groundwater table in the study site varied between zero and 1.0 m for much of the year. In the southern area of the study site regional groundwater flow intersects the surface and forms saturated areas during October to May when precipitation exceeds evapotranspiration, and an open ditch (labeled as Creek B in Fig. 3.1) intercepts subsurface flow. Creek B is solely fed by ground water and is used for stream flow sampling. Small creeks originate from springs on the surrounding hills and drain into the main stream, which flows from north-to-south.

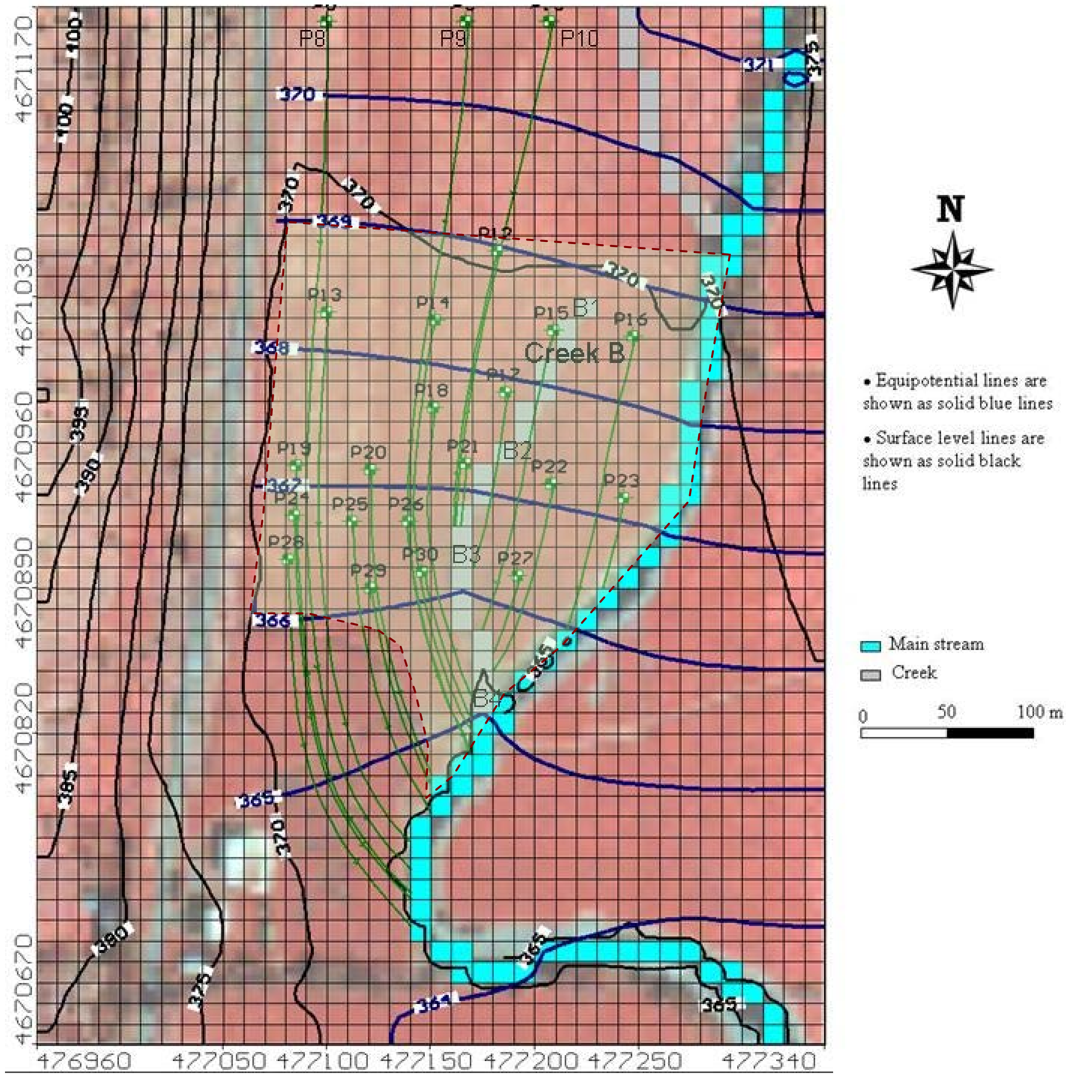


Figure 3.1. Map of groundwater table based equipotential lines for the average state groundwater flow conditions over a period of 672 days showing the streamlines output for the 22 piezometers. The shadow area is a polygon mask applied to the 380 m by 500 m grid design and it is delineated by the corresponding eastern and western edge boundaries, a straight line in the northern edge, and an open ditch in the southern edge joining the main stream water course.

The soils in the study area consist of alluvial soils of the Barbour-Trestle complex (40 percent Barbour and 35 percent Trestle, coarse-loamy-skeletal over sandy or sandy-skeletal, mixed, active, mesic Fluventic Dystrudepts); the principal water-bearing material is Pleistocene sand and gravel (Soren, 1963). Overland flow is absent because of the high infiltration rates of the alluvial soils. Depth to the bedrock is estimated to be approximately 18 m based on measurements from a nearby well (Soren, 1963).

The climate of the Cannonsville Reservoir watershed is humid continental with an average temperature of 8ºC. The annual average precipitation is 112 cm yr^{-1} (National Climatic Data Center, 2000) of which approximately one-third falls as snow. The growing season is from May to September. The nearest weather station is located in Walton, NY, 9 km to the southeast of the field site.

The farm has 60 adult dairy and beef cows and 36 heifers producing 833 Mg (ton) of manure annually. During winter about eighty percent of the manure is spread mainly on the valley bottom lands (average rate of 35 ton ha^{-1}). During the remainder of the year the herd grazes in the pastures.

3.2.2 Groundwater Sampling

Twenty two subsurface PVC piezometers were installed with depths ranging from 0.3 to 1.5 m in the southern field of the study site (Fig. 3.1) to measure water table heights and allow groundwater sampling (Flores-López *et al.*, 2009a). The piezometers were, 3.5 cm in diameter; with a screened length of 0 - 0.3 m from the bottom and wrapped with geosynthetic filter cloth. Piezometers were closed at the bottom and were installed by auguring a hole with a diameter slightly larger than piezometer. The piezometers were then sealed with bentonite to exclude overland flow from entering the piezometer. A total of 542 ground water samples were drawn from the piezometers from July 2004 to April 2006. Capacitance probes (TruTrack Inc, New Zealand) installed adjacent to piezometers measured the groundwater table height on 1 hr intervals.

3.2.3 Stream Sampling

Creek B, which is solely fed by ground water, drains the southern area of the study site. Stream water was sampled at four locations along the course of Creek B (Fig. 3.1) (146 stream water samples collected). Sampling points B2, B3, and B4 were located along Creek B at 65, 130, and 200 m, respectively downstream from B1, which is the source of the Creek. Sampling site B4 was located directly upstream from the confluence with the main stream water course. More information about stream water quality data and analysis are given in (Flores-López *et al.*, 2009b). Piezometers and Creek B were always sampled at the same time with a 15-days-sampling interval, and sampling dates were grouped by season.

3.2.4 Water Chemistry Analysis

Groundwater and stream flow samples were collected at least bimonthly, although often more frequently, from June 2004 through April 2006. Samples were collected using a peristaltic pump rinsed with distilled water before each use. A volume of 100 ml of water was collected in pre-cleaned plastic bottles. Piezometer purging was done prior to sample collection. The pump's output tube was kept in the sampling bottle for the entire pumping duration to allow the groundwater to be well mixed, and to prevent water contact with ambient air during pumping. Water samples were collected with no headspace and stored in coolers to prevent temperature increases during transport to the laboratory. Water samples were filtered through 0.45 μm membrane filters using a vacuum pump filtering system after samples arrived at the laboratory. Filters were washed with 5 ml of distilled water before filtering.

The filtered samples were analyzed for SRP within 24 hours of sampling, or were stored at 4°C until analysis. The samples were analyzed using the OI Analytical FlowSystem 3000 Automated Ascorbic Acid Method for SRP with a detection limit of 0.001 mg L^{-1} following the instructions in the in-house manual for the operation (Method 4500-P G (Ortho-P) and Method 4500-Ph (Total P) In: Apha/Awwa/Wef, 1999).

3.2.5 Modeling of Groundwater Flow and Streamlines

The groundwater flow direction was determined based on the measured water table heights in Visual ModFlow (Waterloo Hydrogeologic Inc., 2005). Streamlines and their length were estimated using MODPATH package (Pollock, 1998). Both streamlines and groundwater flow were determined for average state flow conditions over 672 days (from 06 June 2004 to 30 April 2006) from readings of groundwater table heights. Groundwater table heights were determined at a frequency of 1 hr with capacitance probes (TruTrack, Inc, New Zealand) (resolution of 1 mm) at 22 locations paired with the sampling piezometers (Fig. 3.1). Reference capacitance probe elevations were taken with a laser survey.

The boundary conditions of the ModFlow model consisted of a constant head boundary at the northern edge obtained from the capacitance probes installed adjacent to piezometers P8, P9, and P10 (Fig.3.1). The capacitance probes measured vertical variations in the water table height intercepting the groundwater flux coming from upstream areas. For the southern edge a constant head boundary was defined at the surface water level elevation of the main stream water course (Fig. 3.1). The main stream water course and the shallow bedrock layer along the western hillside were used to define the eastern and western edge boundaries respectively as no-flow boundaries. The 18 m depth of the bedrock layer along the valley bottom was assumed in a smooth transition into the valley bottom from both eastern and western hillslopes based on landscape observations.

The model was calibrated by varying the saturated hydraulic conductivity and the constant head boundaries to obtain the best fit to the observed water table heights averaged over the 672 days period. The calibrated saturated hydraulic conductivity was 10 m d^{-1}.

3.2.6 Spatial Analysis of Groundwater SRP

In order to obtain a spatial pattern of groundwater SRP, kriging interpolation, a statistically-based estimator of spatial variability (Bolstad, 2008), was applied to the measured groundwater SRP concentrations to create prediction maps. Measured groundwater SRP concentrations in piezometers were grouped based on the sampling date then the mean seasonal concentration for each sampling site was used for the spatial analysis. The groundwater SRP concentrations were initially examined by a semivariogram in which a model was chosen for assessing the best goodness of fit. The goal was to generate a smooth experimental semivariogram model for each prediction. Universal kriging interpolation (Western and Oliver, 1989) was performed for extending the spatial autocorrelation of groundwater SRP using the Geostatistical Analyst extension in ArcMap Ver. 9.2 (Environmental Systems Research Institute, 2007). Groundwater SRP concentrations were found to be normal after log-transformation and were, therefore, log-transformed before the empirical semivariogram was calculated:

$$\gamma(h) = \frac{1}{2n(h)} \sum_{i=1}^{n} [z(x_i + h) - z(x_i)]^2 \tag{3.1}$$

where $z(x_i)$ is the groundwater SRP concentration measured at one point, $z(x_i + h)$ is the groundwater SRP concentration measured at another point h distance away (lag distance), n is the number of pairs that are approximately the distance h apart, and $\gamma(h)$ is the semivariance estimate (Bolstad, 2008).

3.2.7 Validation Statistics

Cross-validation was used to evaluate spatial modeling errors given that geostatistical methods provide measure of the uncertainty of the predictions (Environmental Systems Research Institute, 2007). Cross-validation uses all of the data to estimate the trend and autocorrelation models. Then it removes each data location, one at a time, and predicts the associate data value for all points comparing the measured and predicted values. The prediction errors that were measured during the cross-validation include: mean, root-mean-square (RMS), average standard, mean standardized, and RMS standardized. Ideally for all prediction errors, the mean should be near zero, the RMS standardized should be one indicating a perfect fit, and the average standard should be close to the RMS to correctly assess the variability in prediction.

3.3 Results and Discussion

3.3.1 Groundwater and Stream Flow SRP Concentrations

SRP concentrations in groundwater were between 0.003 mg L^{-1} and 0.193 mg L^{-1} with an overall average of 0.034 mg L^{-1}. Average groundwater SRP concentrations were 0.029 mg L^{-1} for summer, 0.048 mg L^{-1} for fall, 0.028 mg L^{-1} for winter, and 0.032 mg L^{-1} for spring (Table 3.1). Our groundwater SRP concentrations are similar to groundwater SRP concentrations reported by Young and Briggs (2008) for crop fields and riparian areas in central New York State. The overall average stream flow SRP concentration in Creek B, which drains groundwater from the area where piezometers were placed, was 0.037 mg L^{-1}. Average stream flow SRP concentrations were 0.035 mg L^{-1} for the summer, 0.046 mg L^{-1} for the fall, 0.044 mg L^{-1} for the winter, and 0.024 mg L^{-1} for the spring (Table 3.1). Sampling of stream flow was primarily performed during baseflow conditions.

3.3.2 Precipitation

The average precipitation during the growing season (May to September) and the non-growing season is 596 mm and 661 mm, respectively (National Climatic Data Center, 2000). A considerable difference was observed between the 2004 and 2005 growing seasons, where 829 mm of precipitation was measured in 2004 but only 311 mm during the 2005 growing season. The two non-growing seasons (October to April 2004-05 and 2005-06, respectively) had precipitation slightly above average, 722 and 751 mm, respectively.

Table 3.1 Mean and range SRP concentrations for the whole monitoring groundwater area, the Creek B watershed, and Creek B for summer, fall, winter and spring.

Season	Sites (count)	Samples (count)	Minimum	Maximum	Mean	Median	SE of Mean	Skewness
			-------------------------	mg L^{-1}	-------------------------			
All Monitoring Ground Water Area								
Summer	16	88	0.009	0.078	0.029	0.019	0.005	1.43
Fall	22	176	0.005	0.193	0.048	0.032	0.011	2.25
Winter	22	130	0.003	0.069	0.028	0.024	0.003	1.23
Spring	22	148	0.010	0.099	0.032	0.025	0.005	1.93
Creek B Watershed								
Summer	7	38	0.013	0.078	0.034	0.020	0.011	1.11
Fall	9	72	0.005	0.193	0.051	0.035	0.019	2.15
Winter	9	55	0.003	0.069	0.026	0.022	0.006	1.75
Spring	9	59	0.010	0.099	0.028	0.019	0.009	2.56
Creek B								
Summer	4	42	0.006	0.239	0.035	0.028	0.006	4.73
Fall	4	47	0.002	0.397	0.046	0.015	0.011	2.97
Winter	4	26	0.002	0.161	0.044	0.027	0.009	1.47
Spring	4	31	0.008	0.175	0.024	0.014	0.005	4.52

3.3.3 Groundwater Flow and Streamlines

To simulate long term average groundwater flow in the monitoring site, a two-dimensional average state ModFlow model was initialized. Equipotential lines, defined using the measured water table heights by averaging readings over a 672 day period, indicated that the direction of the average state groundwater flow was predominately north-south (Fig. 3.1). The fit between the calibrated state and observed average water table height was satisfactory with an $r^2 = 0.76$ (p-value < 0.001) (Fig. 3.2). The modeled groundwater table surface generally followed the ground surface elevation with horizontal hydraulic gradients averaging 0.01. The equipotential lines indicated that Creek B minimally affected the groundwater flow direction, with the exception of a small influence before the confluence of Creek B with the main stream course (Fig. 3.1). The equipotential lines point upstream when they cross Creek B between sampling points B3 and B4, indicating that this was the only segment of Creek B gaining water. This is because the water table height for average conditions rose above the stream bed and fed Creek B. However, throughout the wet season, the

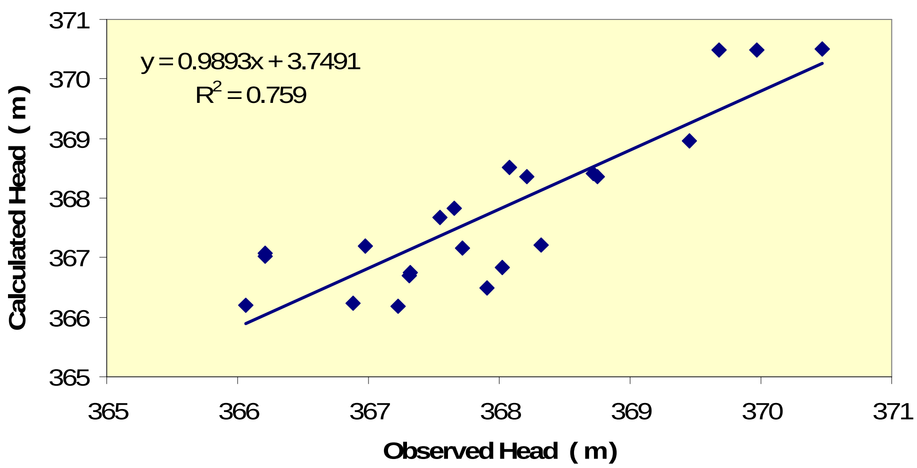


Figure 3.2. Comparison of modeled water heights using ModFlow with the average observed water heights in monitoring piezometers.

entire length of Creek B gained groundwater from sampling point B1 to B4. The streamlines starting from the 22 piezometers are shown in Fig. 3.1. The streamline for P21 had the shortest travel distance (30 m) before reaching Creek B, and P8 had the longest travel distance (420 m) to the main stream water course (Fig. 3.1). Streamlines indicated that only nine of the 22 piezometers influenced Creek B (P10, P12, P15, P17, P18, P21, P22, P27, and P30 in Fig. 3.1). Although there were some piezometers (e.g. P14 and P26 in Fig. 3.1) located a relatively short perpendicular distance from Creek B, streamlines of these piezometers indicate that they did not influence Creek B.

The streamline through the piezometers were connected with the main stream water course, because of the north-to-south groundwater flow direction. The average linear velocity of groundwater flow for the monitoring site was estimated using Darcy's Law:

$$V = -K_s\ (dh / dl)\ /\ n \tag{3.2}$$

Where V is the average linear velocity (m s^{-1}), K_s is the calibrated saturated hydraulic conductivity (m s^{-1}), dh/dl is the hydraulic gradient (m/m) and n is the porosity. Taking the calibrated K_s of 10 m day^{-1} used by the groundwater flow model, the average hydraulic gradient of 0.01, and an estimated bulk porosity of 0.3, the calculated groundwater flow velocity was approximately 0.33 m day^{-1}, or 120 m per year. Hence, the estimated groundwater travel time from P21, which had the shortest travel distance (30 m) to Creek B, was 90 days.

3.3.4 Spatial Variability of Groundwater SRP

To obtain spatial SRP concentration patterns in groundwater and to infer base flow SRP concentrations discharged into streams, kriging interpolation was used. Four seasonal maps were created using log-transformed data. The estimated seasonal groundwater SRP concentration maps at 10-m cell size resolution are shown in Fig. 3.3. Note the two different SRP concentration scales used for the maps, one for the winter, spring and summer, and one for the fall. Distinct spatial patterns emerged in which the greatest estimated concentrations were identified during the fall in the area near Creek B and the confluence with the main stream water course. Concentrations ranged from 0.007 mg L^{-1} in the north- and southeastern area, up to 0.19 mg L^{-1} in

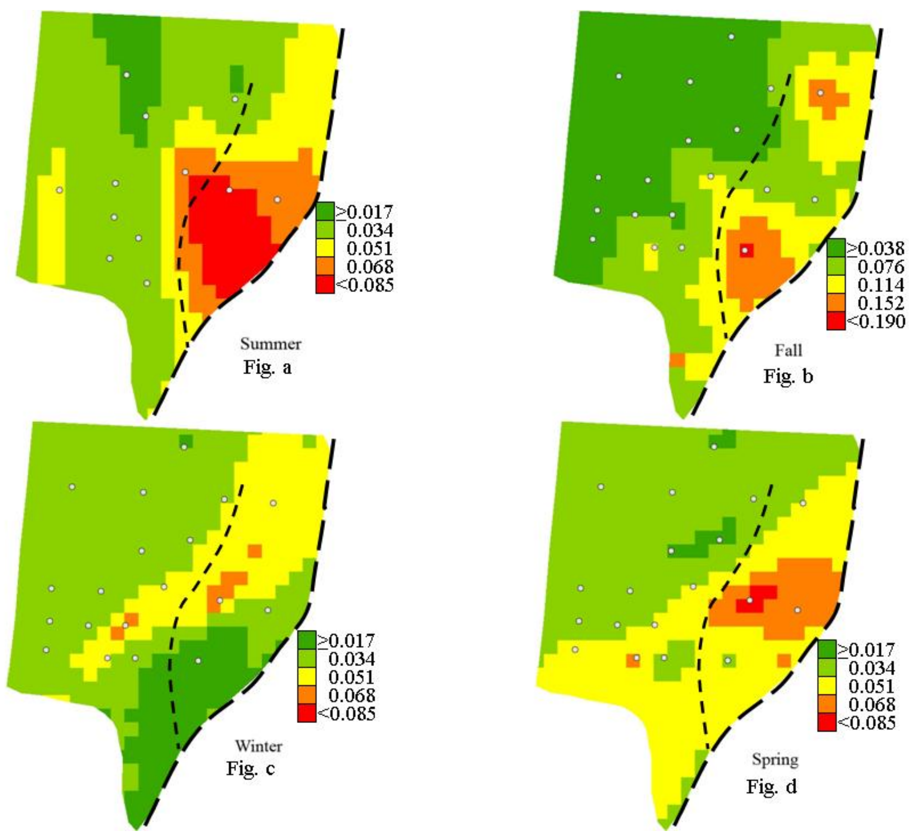


Figure 3.3. Estimated groundwater SRP concentration maps for the summer, fall, winter and spring. Notice that summer, winter, and spring maps have the same concentration scale for predicted values (mg L^{-1}) but the fall map does not. White dots represent the piezometers placed in the field site, the thin dashed line represents Creek B, and the thick dashed line is the main stream water course.

some localized areas between Creek B and the main stream water course (Fig. 3.3b). The lowest estimated SRP concentrations were identified in the upper area defined by a diagonal line going from the northeastern to the southwestern corner during summer, winter and spring. The estimated averages of groundwater SRP concentrations for summer, fall, winter, and spring's maps were 0.034, 0.054, 0.028, and 0.033 mg L^{-1}, respectively, which was similar to the observed concentrations in the groundwater monitoring piezometers of 0.029, 0.048, 0.028, and 0.032 mg L^{-1} (Table 3.1).

However as we will see later, this was by chance since the concentration in the groundwater around creek B was much greater than that in creek B.

The scatter plot of measured data versus estimated values highlights under- and over-estimated concentrations (Fig. 3.4). One might expect that measured and estimated values cluster around the 1:1 line. Estimated regression slope values were 0.80, 0.46, 0.83, and 0.71 for the summer, fall, winter and spring, respectively (Fig. 3.4). For the fall and spring, several data pairs were observed a distance away from the 1:1 line resulting in low observed slope values for these seasons. This indicated a strong under-prediction of SRP concentrations and highlights probable spurious data that

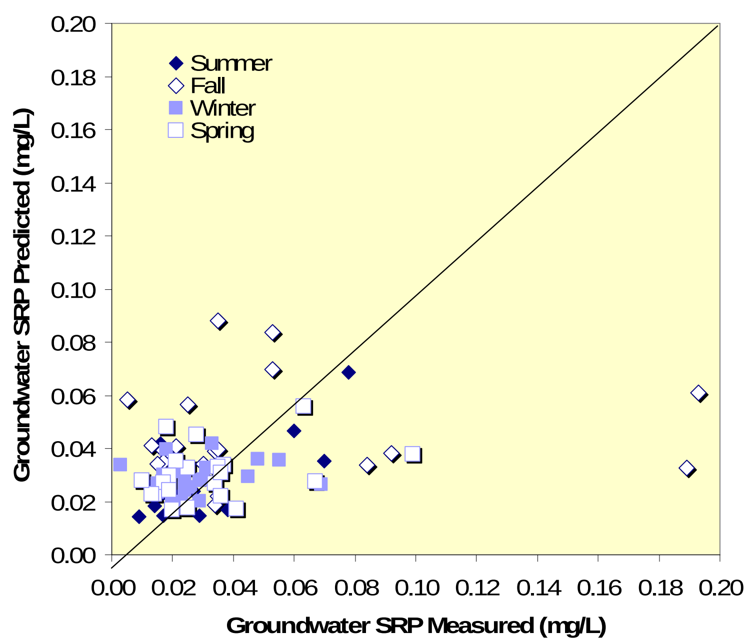


Figure 3.4. Scatter plot of data values (measured versus predicted) of SRP (mg L^{-1}) for the summer, fall, winter and spring. During the fall and spring season, several data pairs were observed away from the 1:1 line resulting in non-strength data. This indicates a strong under-prediction of SRP concentrations and highlights probable spurious data that fall outside confidence limits.

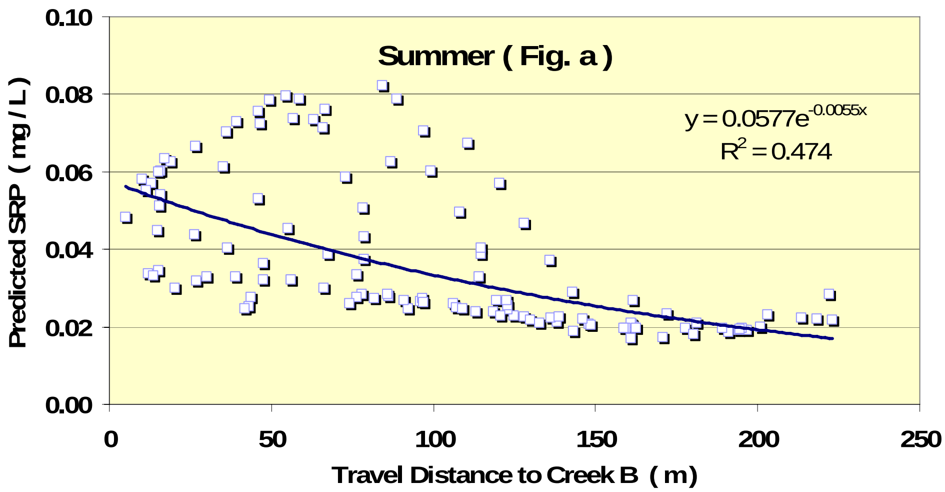
falls outside the confidence limit (Grunwald *et al.*, 2006). Cross-validation results are summarized in Table 3.2. The mean errors were close to zero and indicated acceptable predictions. The root-mean-square (RMS) and average standard errors for the summer, winter, and spring were similar but were larger during the fall. Mean standardized errors were a bit larger than mean errors, indicating that there were insufficient observations to generate robust estimations. Ideally, the RMS standardized of prediction errors should be unity, indicating a perfect fit. The spring and fall RMS standardized were acceptable and reasonably close to unity.

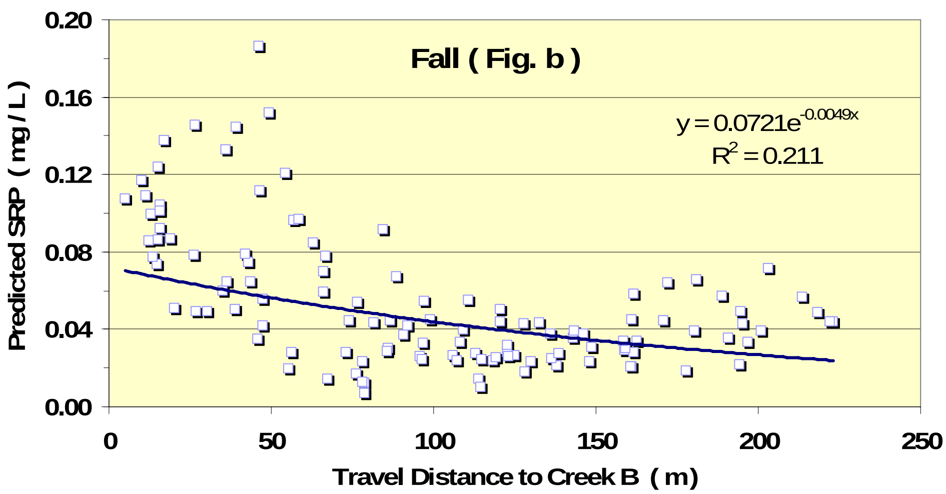
Table 3.2. Prediction error values for the predicted groundwater SRP concentration maps in Fig. 3.2.

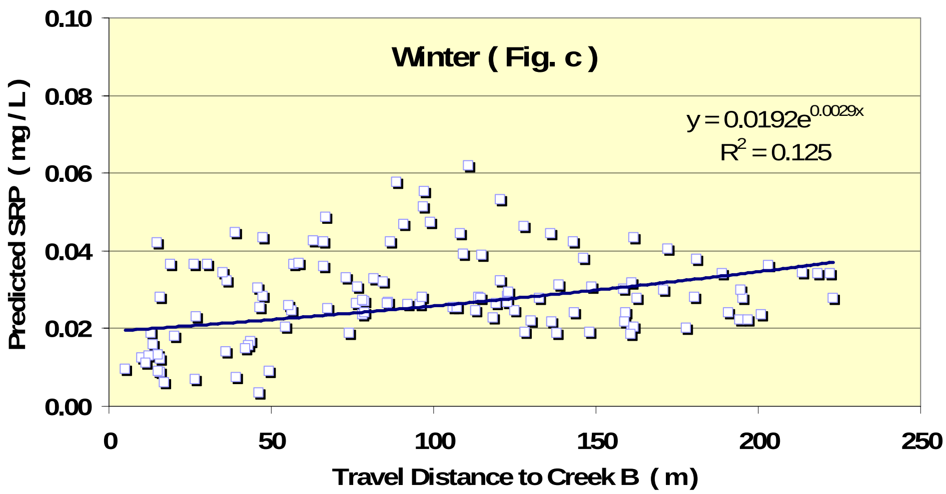
Season	Mean	Root-Mean-Square	Average Standard	Mean Standardized	Root-Mean-Square Standardized
Summer	-0.00103	0.01451	0.02051	-0.12730	0.7551
Fall	-0.00397	0.05156	0.06982	-0.13210	0.8944
Winter	0.00072	0.01473	0.02335	-0.04036	0.7134
Spring	-0.00158	0.01970	0.02171	-0.11570	0.9522

3.3.5 Relation between Spatial Variability of Groundwater SRP and Stream SRP Concentrations

After identifying SRP patterns in groundwater, we attempted to infer its relationship to stream water quality. The equipotential lines indicated that the direction of average groundwater flow was predominately north-to-south; nine of the 22 piezometers intersected Creek B as well (Fig. 3.1). Scatter plots of estimated groundwater SRP concentrations for the area drained by Creek B versus the corresponding distance that streamlines travel before reaching stream itself, and versus depth to the groundwater table, are shown in Figures 3.5 and 3.6, respectively. Summer (Fig. 3.5a), fall (Fig 3.5b), and spring (Fig. 3.5d) scatter plots were fit to an exponential function with a r^2 of 0.47, 0.21, and 0.29 respectively. The exponential fit proves that concentrations increased as the distance to the stream decreased. However, the fit for the winter scatter plot (Fig. 3.5c) was poor, and unlike the other times of the year, some of the concentration decreased in proximity to the stream.







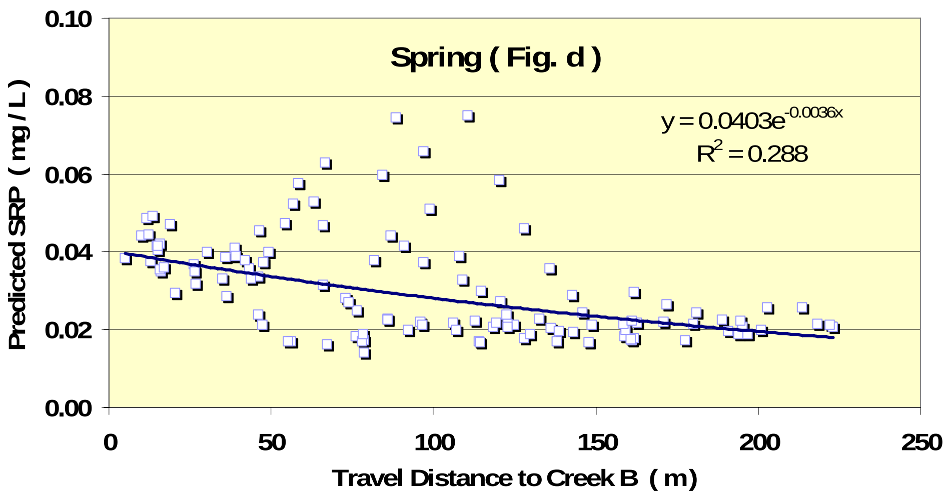
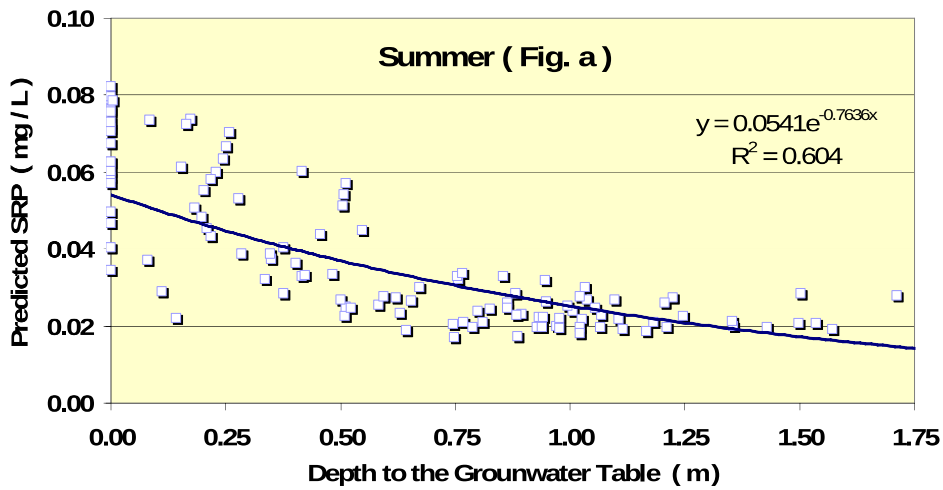
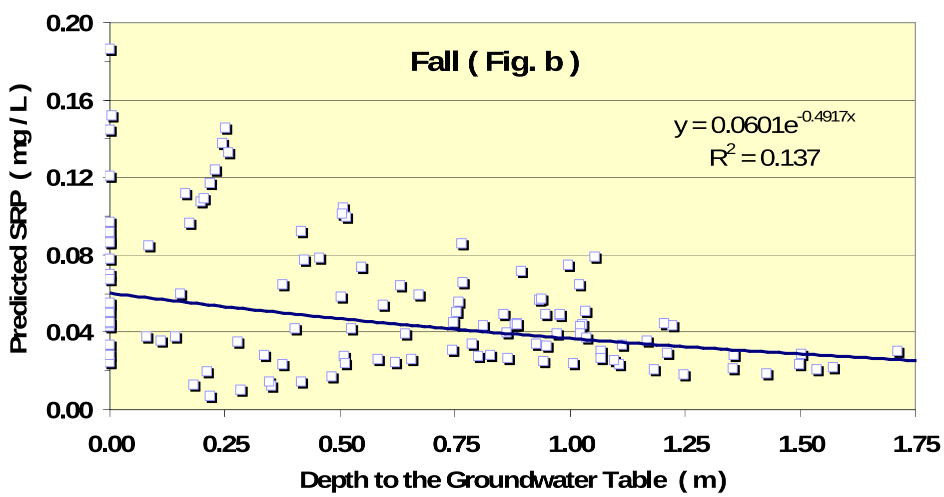


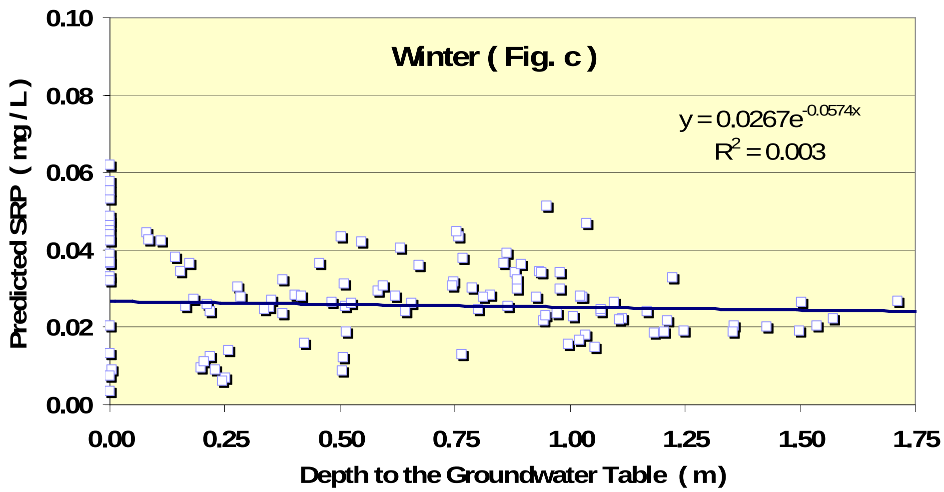
Figure 3.5. Predicted groundwater SRP concentration for each 10-m cell size draining into Creek B based on the predicted groundwater SRP concentration map for summer, fall, winter, and spring and corresponding flow distance to Creek B obtained from the ModFlow model.

Summer, winter and spring scatter plots show that predicted groundwater SRP concentrations above 0.04 mg L^{-1} were located in a distance less than 150 m from Creek B. However, for the fall scatter plot (Fig. 3.5b) predicted groundwater SRP concentrations in some near-stream areas were elevated as much as 0.15 mg L^{-1}, and areas with SRP concentrations above 0.04 mg L^{-1} were predicted to be found a distance of 230 m from the stream. These results indicate that elevated groundwater SRP concentration occurred at distances from less than 10 m up to 150 m from the stream, or even farther during the fall.

In order to examine if the SRP groundwater concentration was related to groundwater depth, the depth to the groundwater table for each 10-m cell size for the Creek B watershed was obtained from ModFlow. The results are plotted in Fig. 3.6. The elevated groundwater SRP patterns were consistent with shallow groundwater table depths and were observed with ground water depths less than 1.0 m for summer, fall and spring (Figs. 3.6 a, b, and d respectively). Their respective exponential fit proves that concentrations also tended to increase as the groundwater table reaches the root zone where P levels are elevated, except winter which has an opposite trend (Fig. 3.6c). Similar to other studies (see below), Creek B SRP concentrations were different from groundwater concentrations for the area feeding Creek B. The average groundwater SRP concentration obtained from Fig. 3.3 for the Creek B watershed during summer, fall, winter and spring were 0.038, 0.054, 0.028 and 0.031 mg L^{-1} respectively. The average Creek B SRP concentrations were significantly different 0.035 for summer, 0.046 fall, 0.044 winter,, and 0.024 mg L^{-1}, spring respectively (Table 3.1; Flores-Lopez *et al.,* 2009a). The largest average differences in concentrations were 0.016, 0.008, and 0.007 mg L^{-1} during winter, fall and spring respectively. Supporting these results a study performed in the same field site where Creek B is located, Flores-Lopez *et al.* (2009a) found a significant difference in average SRP concentrations between ground water sampled in a distance less than 25 m from Creek B (0.050 mg L^{-1}) and the in-stream water of Creek B (0.037 mg L^{-1}). Because the groundwater is closest to the surface in the riparian areas, the increase in SRP concentrations in these riparian areas could be related to the depth at which the samples were taken as shown in Fig. 3.6. However although the concentrations are greater in ground water than in the stream, SRP concentration and stream are elevated when ground water concentration are elevated as in the fall. Since during fall temperatures were still warm, which promoted transformations of P resulting in elevated concentration, the fall was identified as the season which had the greatest SRP concentrations in ground and stream water (Table 3.1).







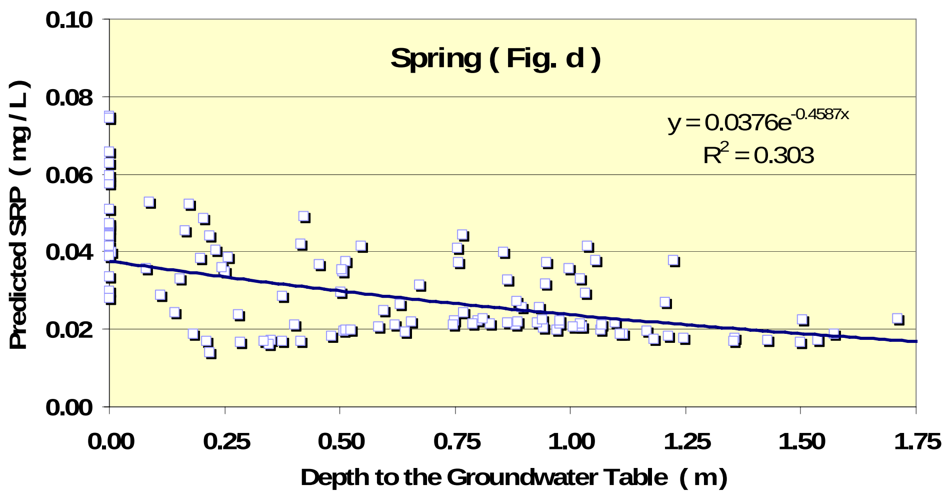


Figure 3.6. Predicted groundwater SRP concentration for each 10-m cell size (open quadrangles) draining into Creek B based on the predicted groundwater SRP concentration map for summer, fall, winter, and spring versus corresponding depth to the ground water table obtained from the ModFlow model.

3.4 Conclusions

Groundwater and stream flow were monitored during a two year period to quantify the impact that an alluvial valley-fill aquifer has on stream water SRP concentrations on a valley dairy farm in the Catskill Mountains of New York State. Modeling of the average state groundwater flow conditions over a period of 672 days was performed using Visual ModFlow. Interpolation techniques were applied to the groundwater SRP measured concentrations to estimate spatial patterns of SRP in the alluvial valley-fill aquifer.

The results of the spatial variability indicated that groundwater SRP concentrations increased as the distance to the streams decreased. Predicted groundwater SRP concentrations larger than a concentration of 0.04 mg L^{-1} occurred at a distance less than 150 m from Creek B during summer, winter and spring. However, during the fall the predicted SRP concentrations in the Creek B watershed were greater than the other three seasons (as much as 0.15 mg L^{-1}) and located in a distance of 230 m from the stream. No relationship was observed between concentrations in the groundwater riparian areas near Creek B and the stream itself; The SRP concentration in the groundwater around Creek B was much greater than that in Creek B. In addition, the SRP patterns were consistent with the greater groundwater SRP concentrations that were observed in the areas with a shallow groundwater table depth and within a short distance to the streams.

This study provides insight into the role that stream buffers and riparian areas have on controlling stream SRP concentrations although it does not point to the width of riparian buffers as a key factor for BMP effectiveness.

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CHAPTER 4

GENERAL CONCLUSIONS

Agricultural areas are assumed to contribute excessive nutrients to surface and ground water. However, little research has explored the impact of agricultural activity on alluvial valley soils in mountainous terrain. In the Catskills Mountains of New York State, which supplies drinking water to New York City, the alluvial valley-fill aquifers provide the source of the base flow to most streams in the region. These valley bottom lands are utilized for intensive agricultural production, and have been identified as a contributor of nonpoint source P and N to surface waters (Brown *et al.* 1989; Hively *et al.* 2005). Therefore, agricultural producers have faced pressure to reduce or more efficiently manage nutrients, particularly from animal waste sources (i.e., manure) to minimize the addition of contaminants to water bodies. This is particularly important in the New York City source watersheds where local economic development can be reduced when in-reservoir water P levels are above the New York State Department of Environmental Conservation (NYSDEC) maximum allowed standard of 20 $\mu g\ L^{-1}$ (NYSDEC 1993). Nitrate concentrations also may pose a threat to water quality at lower levels of the 10 mg L^{-1} standard for drinking water (US Environmental Protection Agency 2003).

The study area experiences intense farming year round and is located on an alluvial valley plain in the Catskill Mountains, upstream of the Cannonsville Reservoir. This reservoir is one of the drinking water sources to New York City. Soluble reactive phosphorus (SRP) and nitrate-N (NO_3^--N) concentrations were measured in 37 groundwater sampling wells, and 11 locations in two streams in an alluvial valley farm to assess the impact of agricultural activity on stream water quality. During the study period the farm implemented several near stream best management practices (BMPs), which allowed comparative analysis of the impact of BMPs on water quality. These studies were conducted from October 2003 through April 2006.

Analysis of measured SRP concentrations from shallow wells indicated that groundwater concentrations in the near stream area were not correlated with the in-stream concentrations. Despite over 100 years of manure application on the study farm, stream SRP concentrations were generally below 0.1 mg L^{-1}, with an average of 0.037 mg L^{-1}, significantly less than those reported from surrounding hillside farms. The highest SRP concentrations were consistently measured at the shallowest groundwater depths. The NO_3^--N concentrations varied from the detection limit of 0.05 to 5 mg L^{-1} with an average of 2.2 mg L^{-1} similar to levels reported from other agricultural areas in the Catskills.

The implementation of near stream BMPs, consisting of exclusionary fencing and cattle crossings, resulted in a reduction of in-stream SRP concentration of 33% (0.008 mg L^{-1}) during the growing season and a reduction of 26% (0.005 mg L^{-1}) annually. There was no detectable effect of the BMPs during the non-growing season. The observed in-stream NO_3^--N concentrations remained well below the 10 mg L^{-1} standard for drinking water throughout the length of this study, and effects of near stream BMPs analyses indicated that the NO_3^--N concentrations did not appear to be influenced by the BMP. Evidence for low SRP concentrations in streams, irrespective of BMP installation, indicates that valley bottom daily farms may not be as significant a source of nutrient loading to the Cannonsville reservoir watershed as many of the upland farms.

Results of the spatial variability of groundwater SRP indicated that SRP concentration in groundwater increased as the distance to the stream decreased. A good relationship between concentrations in the groundwater riparian areas near stream and the stream itself was not found; the SRP concentration in the groundwater around the stream was much greater than that in the stream. Temperature throughout the soil profile and depth to the groundwater table played an important role in the temporal availability of SRP in groundwater.

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APPENDIX A

Source Data from Groundwater Sampling Sites

Sampling Site (n/a)	Sampling Date (mm/dd/yy)	Season and year (n/a)	SRP (mg L^{-1})	NO_3^--N (mg L^{-1})	DO (mg L^{-1})	DOC (mg L^{-1})	GWTD (m)	Land Cover (n/a)	Spreading Manure (n/a)	Rainfall (cm)	Season (n/a)
P1	11/5/03	Fall03	0.025					Alfalfa	1	0.0	Fall
P1	11/18/03	Fall03	0.015					Alfalfa	1	0.2	Fall
P1	12/2/03	Fall03	0.032					Alfalfa	1	0.5	Fall
P1	12/13/03	Fall03	0.027					Alfalfa	1	3.5	Fall
P1	1/24/04	Winter03/04	0.023					Alfalfa	0	0.0	Winter
P1	2/6/04	Winter03/04	0.011					Alfalfa	0	0.5	Winter
P1	2/21/04	Winter03/04	0.001					Alfalfa	0	0.3	Winter
P1	3/15/04	Winter03/04	0.018					Alfalfa	0	0.0	Winter
P1	3/25/04	Winter03/04	0.007					Alfalfa	0	0.2	Winter
P1	4/14/04	Spring04	0.024	2.365			0.54	Alfalfa	0	3.4	Spring
P1	5/1/04	Spring04		1.682			0.61	Alfalfa	0	0.0	Spring
P1	5/10/04	Spring04	0.005	1.207			0.59	Alfalfa	0	0.8	Spring
P1	5/27/04	Spring04	0.014				0.65	Alfalfa	0	1.8	Spring
P1	6/10/04	Spring04	0.006	1.693			0.65	Alfalfa	0	0.7	Spring
P1	6/23/04	Summer04	0.082	1.936			0.74	Alfalfa	0	0.1	Summer
P1	7/5/04	Summer04	0.072				0.74	Alfalfa	0	0.1	Summer
P1	7/19/04	Summer04	0.014	2.707			0.71	Alfalfa	0	2.0	Summer
P1	8/2/04	Summer04	0.010	1.628			0.53	Alfalfa	0	0.2	Summer
P1	8/16/04	Summer04	0.005	1.417			0.64	Alfalfa	0	2.6	Summer
P1	9/4/04	Summer04		0.058			0.73	Alfalfa	0	0.0	Summer
P1	9/19/04	Summer04	0.041	0.288			0.23	Alfalfa	0	5.4	Summer

P1	9/21/04	Summer04	0.022				0.33	Alfalfa	0	0.0	Summer
P1	9/24/04	Fall04	0.018				0.43	Alfalfa	0	0.1	Fall
P1	9/30/04	Fall04	0.013				0.46	Alfalfa	0	3.0	Fall
P1	10/16/04	Fall04	0.009				0.56	Alfalfa	1	2.1	Fall
P1	11/4/04	Fall04	0.005				0.66	Alfalfa	1	0.5	Fall
P1	11/20/04	Fall04	0.004				0.73	Alfalfa	1	0.4	Fall
P1	12/4/04	Fall04	0.008				0.40	Alfalfa	1	0.0	Fall
P1	12/16/04	Fall04	0.023				0.47	Alfalfa	1	0.1	Fall
P1	1/30/05	Winter04/05	0.015		1.7	2.1	0.52	Alfalfa	0	0.0	Winter
P1	2/17/05	Winter04/05	0.018			1.7	0.46	Alfalfa	0	0.7	Winter
P1	3/7/05	Winter04/05	0.019		4.0	1.6	0.65	Alfalfa	0	0.6	Winter
P1	3/30/05	Spring05	0.017		3.7	1.7	0.31	Alfalfa	0	3.6	Spring
P1	4/5/05	Spring05	0.012		2.7	0.7	0.34	Alfalfa	0	0.1	Spring
P1	4/21/05	Spring05	0.010	0.857	2.2	0.6	0.61	Alfalfa	0	0.6	Spring
P1	5/8/05	Spring05	0.013	0.600	2.9	1.0	0.60	Alfalfa	0	0.0	Spring
P1	6/30/05	Summer05	0.029				0.75	Alfalfa	0	3.3	Summer
P1	10/12/05	Fall05	0.084		3.6	3.5		Alfalfa	1	3.3	Fall
P1	10/29/05	Fall05	0.015		4.1	1.7		Alfalfa	1	0.0	Fall
P1	11/15/05	Fall05	0.017		3.7	1.4	0.46	Alfalfa	1	1.4	Fall
P1	12/1/05	Fall05	0.001		5.3	1.2	0.43	Alfalfa	1	0.2	Fall
P1	1/13/06	Winter05/06	0.003		2.9	1.1	0.52	Alfalfa	0	0.1	Winter
P1	2/1/06	Winter05/06	0.004		3.4	2.4	0.50	Alfalfa	0	0.8	Winter
P1	2/20/06	Winter05/06	0.002		10.5	4.5	0.63	Alfalfa	0	0.0	Winter
P1	3/12/06	Winter05/06	0.006		3.7	0.9	0.72	Alfalfa	0	0.0	Winter
P1	3/29/06	Spring06	0.013		3.9	0.0	0.66	Alfalfa	0	0.0	Spring
P1	4/15/06	Spring06	0.010		2.8	0.8	0.61	Alfalfa	0	1.3	Spring
P1	4/30/06	Spring06	0.013		3.4	0.1	0.51	Alfalfa	0	0.0	Spring
P2	11/5/03	Fall03	0.025					Alfalfa	1	0.0	Fall
P2	11/18/03	Fall03	0.007					Alfalfa	1	0.2	Fall
P2	12/2/03	Fall03	0.029					Alfalfa	1	0.5	Fall

P2	12/13/03	Fall03	0.027					Alfalfa	1	3.5	Fall
P2	3/5/04	Winter03/04	0.383					Alfalfa	0	0.9	Winter
P2	3/15/04	Winter03/04	0.183					Alfalfa	0	0.0	Winter
P2	3/25/04	Winter03/04	0.132					Alfalfa	0	0.2	Winter
P2	4/14/04	Spring04	0.045	2.716			0.98	Alfalfa	0	3.4	Spring
P2	5/1/04	Spring04	0.002	0.215			0.74	Alfalfa	0	0.0	Spring
P2	5/10/04	Spring04	0.014	2.029			0.72	Alfalfa	0	0.8	Spring
P2	5/27/04	Spring04	0.019				0.90	Alfalfa	0	1.8	Spring
P2	6/10/04	Spring04	0.016	1.885			0.88	Alfalfa	0	0.7	Spring
P2	6/23/04	Summer04	0.039	1.936			1.10	Alfalfa	0	0.1	Summer
P2	7/5/04	Summer04					1.08	Alfalfa	0	0.1	Summer
P2	7/19/04	Summer04	0.012	2.162			0.91	Alfalfa	0	2.0	Summer
P2	8/2/04	Summer04	0.011	1.506			0.66	Alfalfa	0	0.2	Summer
P2	8/16/04	Summer04	0.012				0.81	Alfalfa	0	2.6	Summer
P2	9/4/04	Summer04	0.043	0.107			0.93	Alfalfa	0	0.0	Summer
P2	9/19/04	Summer04	0.100	0.358			0.33	Alfalfa	0	5.4	Summer
P2	9/21/04	Summer04	0.037				0.48	Alfalfa	0	0.0	Summer
P2	9/24/04	Fall04	0.017				0.56	Alfalfa	0	0.1	Fall
P2	9/30/04	Fall04	0.015				0.58	Alfalfa	0	3.0	Fall
P2	10/16/04	Fall04	0.296				0.73	Alfalfa	1	2.1	Fall
P2	11/4/04	Fall04	0.011				0.88	Alfalfa	1	0.5	Fall
P2	11/20/04	Fall04	0.010				0.97	Alfalfa	1	0.4	Fall
P2	12/4/04	Fall04	0.249				0.57	Alfalfa	1	0.0	Fall
P2	12/16/04	Fall04	0.105				0.65	Alfalfa	1	0.1	Fall
P2	1/30/05	Winter04/05	0.018		2.7	4.5	0.69	Alfalfa	0	0.0	Winter
P2	2/17/05	Winter04/05	0.023			1.3	0.70	Alfalfa	0	0.7	Winter
P2	3/7/05	Winter04/05	0.017		3.5	1.4	0.87	Alfalfa	0	0.6	Winter
P2	3/30/05	Spring05	0.044		3.5	9.2	0.53	Alfalfa	0	3.6	Spring
P2	4/5/05	Spring05	0.024		2.7	1.5	0.50	Alfalfa	0	0.1	Spring
P2	4/21/05	Spring05	0.030	1.028	2.7	1.5	0.77	Alfalfa	0	0.6	Spring

P2	5/8/05	Spring05	0.021	0.686	2.7	3.6	0.76	Alfalfa	0	0.0	Spring
P2	6/30/05	Summer05	0.239		3.5	5.1	1.02	Alfalfa	0	3.3	Summer
P2	7/20/05	Summer05					1.07	Alfalfa	0	0.1	Summer
P2	9/1/05	Summer05					1.11	Alfalfa	0	1.5	Summer
P2	9/20/05	Summer05					1.23	Alfalfa	0	0.2	Summer
P2	9/27/05	Fall05					1.23	Alfalfa	0	2.7	Fall
P2	10/12/05	Fall05					1.07	Alfalfa	1	3.3	Fall
P2	10/29/05	Fall05	0.107		6.3	2.5	0.64	Alfalfa	1	0.0	Fall
P2	11/15/05	Fall05	0.104	0.087	4.5	2.6		Alfalfa	1	1.4	Fall
P2	12/1/05	Fall05	0.067		4.4	1.2		Alfalfa	1	0.2	Fall
P2	1/13/06	Winter05/06	0.016		5.5	1.0		Alfalfa	0	0.1	Winter
P2	2/1/06	Winter05/06	0.009		2.4	8.2		Alfalfa	0	0.8	Winter
P2	2/20/06	Winter05/06	0.016		11.0	3.4		Alfalfa	0	0.0	Winter
P2	3/29/06	Spring06	0.015		4.8	0.4		Alfalfa	0	0.0	Spring
P2	4/15/06	Spring06	0.037		2.3	12.6		Alfalfa	0	1.3	Spring
P2	4/30/06	Spring06	0.053		3.0	0.1		Alfalfa	0	0.0	Spring
P3	9/19/04	Summer04	0.019	0.311			0.61	Corn	0	5.4	Summer
P3	9/21/04	Summer04	0.020	0.600			0.79	Corn	0	0.0	Summer
P3	9/24/04	Fall04	0.021				0.97	Corn	0	0.1	Fall
P3	9/30/04	Fall04	0.025				0.99	Corn	0	3.0	Fall
P3	2/17/05	Winter04/05	0.341			11.5	0.90	Corn	0	0.7	Winter
P3	3/30/05	Spring05			0.5	28.8	0.67	Corn	0	3.6	Spring
P3	4/5/05	Spring05			0.1	21.3	0.70	Corn	0	0.1	Spring
P5	8/2/04	Summer04	0.008	1.749			1.41	Corn	0	0.2	Summer
P5	8/16/04	Summer04	0.069				1.50	Corn	0	2.6	Summer
P5	9/19/04	Summer04	0.020	0.276			0.93	Corn	0	5.4	Summer
P5	9/21/04	Summer04	0.016	0.343			1.17	Corn	0	0.0	Summer
P5	9/24/04	Fall04	0.230				1.31	Corn	0	0.1	Fall
P5	9/30/04	Fall04	0.012	0.925			1.34	Corn	0	3.0	Fall
P5	10/16/04	Fall04	0.038				1.15	Corn	0	2.1	Fall

P5	11/4/04	Fall04	0.118				1.29	Corn	0	0.5	Fall
P5	12/4/04	Fall04	0.029				1.13	Corn	0	0.0	Fall
P5	12/16/04	Fall04	0.021				1.18	Corn	0	0.1	Fall
P5	5/8/05	Spring05	0.040	3.340	0.0	22.4	1.39	Corn	1	0.0	Spring
P6	9/19/04	Summer04	0.039	0.335				Alfalfa	0	5.4	Summer
P6	9/21/04	Summer04	0.044	0.343				Alfalfa	0	0.0	Summer
P6	11/20/04	Fall04	0.066					Alfalfa	0	0.4	Fall
P6	3/30/05	Spring05	0.961		3.3	6.5	0.57	Alfalfa	1	3.6	Spring
P6	4/5/05	Spring05	0.054		2.6	3.6	0.35	Alfalfa	0	0.1	Spring
P6	6/30/05	Summer05	0.028			1.4	1.08	Corn	0	3.3	Summer
P6	9/1/05	Summer05	0.019	0.515	4.0	4.0	1.06	Corn	0	1.5	Summer
P6	10/12/05	Fall05	0.386	2.827	3.3	3.0	1.05	Corn	0	3.3	Fall
P6	10/29/05	Fall05	0.164	3.255	6.6	9.0	0.79	Corn	0	0.0	Fall
P6	11/15/05	Fall05	0.102	0.943	4.1	2.0	0.83	Corn	0	1.4	Fall
P6	12/1/05	Fall05	0.356		3.2	5.4	0.63	Corn	0	0.2	Fall
P6	1/13/06	Winter05/06	0.054		2.6	2.2	0.78	Corn	1	0.1	Winter
P6	2/1/06	Winter05/06	0.047		2.9	3.7	0.72	Corn	1	0.8	Winter
P6	2/20/06	Winter05/06	0.030		11.0	5.0	0.92	Corn	1	0.0	Winter
P6	3/12/06	Winter05/06			1.0		0.96	Corn	1	0.0	Winter
P6	3/29/06	Spring06					0.88	Corn	0	0.0	Spring
P6	4/15/06	Spring06	0.059		2.6	1.2	0.87	Corn	0	1.3	Spring
P6	4/30/06	Spring06	0.060		4.5	0.1	0.79	Corn	0	0.0	Spring
P7	7/19/04	Summer04	0.017	2.162			0.93	Alfalfa	0	2.0	Summer
P7	8/2/04	Summer04	0.006	5.332			0.65	Alfalfa	0	0.2	Summer
P7	8/16/04	Summer04	0.022				1.03	Alfalfa	0	2.6	Summer
P7	9/4/04	Summer04	0.007	0.049			1.08	Alfalfa	0	0.0	Summer
P7	9/19/04	Summer04	0.016	0.346			0.41	Alfalfa	0	5.4	Summer
P7	9/21/04	Summer04	0.010	0.343			0.68	Alfalfa	0	0.0	Summer
P7	9/24/04	Fall04	0.018				0.82	Alfalfa	0	0.1	Fall
P7	9/30/04	Fall04	0.017				0.82	Alfalfa	0	3.0	Fall

P7	11/4/04	Fall04	0.010				0.96	Alfalfa	0	0.5	Fall
P7	11/20/04	Fall04	0.006				1.00	Alfalfa	0	0.4	Fall
P7	12/4/04	Fall04	0.012				0.74	Alfalfa	0	0.0	Fall
P7	12/16/04	Fall04	0.019				0.83	Alfalfa	0	0.1	Fall
P7	2/17/05	Winter04/05	0.019			1.4	0.83	Alfalfa	0	0.7	Winter
P7	3/7/05	Winter04/05	0.033		7.0	0.9	0.96	Alfalfa	0	0.6	Winter
P7	3/30/05	Spring05	0.226		4.5	5.8	0.36	Alfalfa	1	3.6	Spring
P7	4/5/05	Spring05	0.032		3.5	2.3	0.42	Alfalfa	1	0.1	Spring
P7	4/21/05	Spring05	0.016	0.772	4.6	0.3	0.94	Alfalfa	1	0.6	Spring
P7	5/8/05	Spring05	0.015	0.600	4.2	1.1	0.94	Alfalfa	1	0.0	Spring
P7	10/29/05	Fall05	0.021		7.1			Alfalfa	0	0.0	Fall
P7	11/15/05	Fall05	0.064	1.114	7.7	1.3	0.75	Alfalfa	0	1.4	Fall
P7	12/1/05	Fall05	0.016		6.7	1.7	0.76	Alfalfa	0	0.2	Fall
P7	1/13/06	Winter05/06	0.010		3.9	0.9	0.75	Alfalfa	0	0.1	Winter
P7	3/29/06	Spring06	0.015		4.9	0.0		Alfalfa	1	0.0	Spring
P7	4/15/06	Spring06	0.009		3.4	0.7	0.57	Alfalfa	1	1.3	Spring
P8	8/2/04	Summer04	0.008	5.514			1.26	Corn	0	0.2	Summer
P8	8/16/04	Summer04	0.002				1.54	Corn	0	2.6	Summer
P8	9/19/04	Summer04	0.013	0.299			0.72	Corn	0	5.4	Summer
P8	9/21/04	Summer04	0.010	0.429			0.72	Corn	0	0.0	Summer
P8	9/24/04	Fall04	0.016				0.96	Corn	0	0.1	Fall
P8	9/30/04	Fall04	0.014				0.96	Corn	0	3.0	Fall
P8	12/4/04	Fall04	0.020				0.79	Corn	0	0.0	Fall
P8	12/16/04	Fall04	0.019				1.00	Corn	0	0.1	Fall
P8	2/17/05	Winter04/05	0.020			2.1	1.32	Corn	1	0.7	Winter
P8	3/30/05	Spring05	0.054		3.4	4.6	0.72	Corn	1	3.6	Spring
P8	4/5/05	Spring05	0.027		3.2	3.5	0.72	Corn	1	0.1	Spring
P9	8/2/04	Summer04	0.007	7.458			1.26	Alfalfa	0	0.2	Summer
P9	8/16/04	Summer04	0.004	1.366			1.47	Alfalfa	0	2.6	Summer
P9	9/19/04	Summer04	0.014	0.323			0.69	Alfalfa	0	5.4	Summer

P9	9/21/04	Summer04	0.010	0.515			0.74	Alfalfa	0	0.0	Summer
P9	9/24/04	Fall04	0.013	3.321			0.94	Alfalfa	0	0.1	Fall
P9	9/30/04	Fall04	0.014				1.06	Alfalfa	0	3.0	Fall
P9	10/16/04	Fall04	0.013				1.42	Alfalfa	0	2.1	Fall
P9	12/4/04	Fall04	0.010				1.05	Alfalfa	0	0.0	Fall
P9	12/16/04	Fall04	0.015				1.20	Alfalfa	0	0.1	Fall
P9	2/17/05	Winter04/05	0.020			0.9	1.09	Alfalfa	1	0.7	Winter
P9	3/30/05	Spring05	0.025		3.8	1.9	0.83	Alfalfa	1	3.6	Spring
P9	4/5/05	Spring05	0.013		3.0	2.5	0.73	Alfalfa	0	0.1	Spring
P9	5/8/05	Spring05	0.013	0.429	4.0	0.9	1.38	Alfalfa	0	0.0	Spring
P9	10/12/05	Fall05	0.139	1.028	4.3	10.7	1.16	Corn	0	3.3	Fall
P9	10/29/05	Fall05	0.057	26.375	3.0	2.1	0.90	Corn	0	0.0	Fall
P9	11/15/05	Fall05					1.08	Corn	0	1.4	Fall
P9	12/1/05	Fall05	0.011		5.1	1.0	0.69	Corn	0	0.2	Fall
P9	1/13/06	Winter05/06					0.96	Corn	1	0.1	Winter
P9	2/1/06	Winter05/06	0.009		3.8	3.2	0.96	Corn	1	0.8	Winter
P9	2/20/06	Winter05/06					1.31	Corn	1	0.0	Winter
P9	3/12/06	Winter05/06					1.31	Corn	1	0.0	Winter
P9	4/15/06	Spring06					1.31	Corn	1	1.3	Spring
P9	4/30/06	Spring06					1.16	Corn	1	0.0	Spring
P10	8/2/04	Summer04	0.012	5.271			1.25	Alfalfa	0	0.2	Summer
P10	8/16/04	Summer04	0.014	1.816			1.34	Alfalfa	0	2.6	Summer
P10	9/4/04	Summer04	0.014	0.058			1.44	Alfalfa	0	0.0	Summer
P10	9/19/04	Fall04	0.016	0.288			0.63	Alfalfa	0	5.4	Summer
P10	9/21/04	Fall04	0.089	0.429			0.80	Alfalfa	0	0.0	Summer
P10	9/24/04	Fall04	0.016	0.619			1.02	Alfalfa	0	0.1	Fall
P10	9/30/04	Fall04	0.023				1.02	Alfalfa	0	3.0	Fall
P10	10/16/04	Fall04	0.012				1.39	Alfalfa	0	2.1	Fall
P10	11/20/04	Fall04	0.007				1.54	Alfalfa	0	0.4	Fall
P10	12/4/04	Winter04/05	0.011				1.04	Alfalfa	0	0.0	Fall

P10	12/16/04	Winter04/05	0.020				1.23	Alfalfa	0	0.1	Fall
P10	1/30/05	Winter04/05	0.019		4.9	2.5	1.35	Alfalfa	1	0.0	Winter
P10	2/17/05	Spring05	0.020			3.9	1.09	Alfalfa	1	0.7	Winter
P10	3/7/05	Spring05	0.029		5.2	5.1	1.46	Alfalfa	1	0.6	Winter
P10	3/30/05	Spring05	0.031		3.4	3.1	0.87	Alfalfa	1	3.6	Spring
P10	4/5/05	Spring05	0.023		3.0	2.0	1.03	Alfalfa	0	0.1	Spring
P10	4/21/05	Summer05	0.012	1.028	4.4	0.3	1.33	Alfalfa	0	0.6	Spring
P10	5/8/05	Summer05	0.015	1.200	4.6	0.7	1.41	Alfalfa	0	0.0	Spring
P12	8/2/04	Summer04	0.013	7.397			0.48	Alfalfa	0	0.2	Summer
P12	9/4/04	Summer04	0.012	0.049			0.70	Alfalfa	0	0.0	Summer
P12	9/19/04	Summer04	0.014	0.311			0.28	Alfalfa	0	5.4	Summer
P12	9/21/04	Summer04	0.015	0.429			0.24	Alfalfa	0	0.0	Summer
P12	9/24/04	Fall04	0.012				0.22	Alfalfa	0	0.1	Fall
P12	9/30/04	Fall04	0.016				0.22	Alfalfa	0	3.0	Fall
P12	10/16/04	Fall04	0.009				0.59	Alfalfa	0	2.1	Fall
P12	11/20/04	Fall04	0.010				0.73	Alfalfa	0	0.4	Fall
P12	12/4/04	Fall04	0.014					Alfalfa	0	0.0	Fall
P12	12/16/04	Fall04	0.018					Alfalfa	0	0.1	Fall
P12	2/17/05	Winter04/05	0.016			1.4		Alfalfa	1	0.7	Winter
P12	3/7/05	Winter04/05	0.025		5.1	1.5		Alfalfa	1	0.6	Winter
P12	3/30/05	Spring05	0.017		3.7	1.2		Alfalfa	1	3.6	Spring
P12	4/5/05	Spring05	0.016		3.0	1.4		Alfalfa	0	0.1	Spring
P12	4/21/05	Spring05	0.008	1.885	3.2	0.4		Alfalfa	0	0.6	Spring
P12	5/8/05	Spring05	0.009	0.686	3.9	0.7		Alfalfa	0	0.0	Spring
P12	10/29/05	Fall05	0.015	28.344	3.3	3.9	0.23	Corn	0	0.0	Fall
P12	11/15/05	Fall05					0.38	Corn	0	1.4	Fall
P12	12/1/05	Fall05	0.007		4.1	2.0	0.28	Corn	0	0.2	Fall
P12	1/13/06	Winter05/06					0.48	Corn	1	0.1	Winter
P12	2/1/06	Winter05/06	0.004		3.7	3.2	0.50	Corn	1	0.8	Winter
P13	11/4/04	Fall04	0.019				0.72	Corn	0	0.5	Fall

P13	11/20/04	Fall04	0.020				0.79	Corn	0	0.4	Fall
P13	12/4/04	Fall04	0.017				0.22	Corn	0	0.0	Fall
P13	12/16/04	Fall04	0.019				0.35	Corn	0	0.1	Fall
P13	1/30/05	Winter04/05	0.027		2.7	6.8	0.20	Corn	1	0.0	Winter
P13	2/17/05	Winter04/05	0.054			8.1	0.30	Corn	1	0.7	Winter
P13	3/30/05	Spring05	0.035		3.5	2.8	0.06	Corn	1	3.6	Spring
P13	4/5/05	Spring05	0.013		3.2	1.4	0.00	Corn	1	0.1	Spring
P13	4/21/05	Spring05	0.010	1.028	2.7	0.8	0.56	Corn	1	0.6	Spring
P13	5/8/05	Spring05	0.016	0.429	2.7	1.7	0.55	Corn	1	0.0	Spring
P13	10/29/05	Fall05	0.011	16.356	3.2	3.9	0.15	Corn	0	0.0	Fall
P13	11/15/05	Fall05	0.028	0.600	8.3	2.1	0.26	Corn	0	1.4	Fall
P13	12/1/05	Fall05	0.008		3.9	0.8	0.33	Corn	0	0.2	Fall
P13	1/13/06	Winter05/06	0.004		2.7	0.8	0.31	Corn	1	0.1	Winter
P13	2/1/06	Winter05/06	0.003		3.0	3.0	0.25	Corn	1	0.8	Winter
P13	2/20/06	Winter05/06	0.011		11.2	3.3	0.48	Corn	1	0.0	Winter
P13	3/12/06	Winter05/06	0.042		3.5	9.3	0.62	Corn	1	0.0	Winter
P13	3/29/06	Spring06	0.012		3.6	0.6	0.54	Corn	1	0.0	Spring
P13	4/15/06	Spring06	0.011		2.6	1.0	0.56	Corn	1	1.3	Spring
P13	4/30/06	Spring06	0.022		3.2	0.1	0.28	Corn	1	0.0	Spring
P14	12/4/04	Fall04	0.016				0.25	Alfalfa	0	0.0	Fall
P14	12/16/04	Fall04	0.023				0.41	Alfalfa	0	0.1	Fall
P14	2/17/05	Winter04/05	0.036			6.7	0.18	Alfalfa	1	0.7	Winter
P14	3/7/05	Winter04/05	0.040		7.3	2.3	0.55	Alfalfa	1	0.6	Winter
P14	3/30/05	Spring05	0.048		2.5	16.9	0.18	Alfalfa	1	3.6	Spring
P14	4/5/05	Spring05	0.022		2.8	2.1	0.18	Alfalfa	1	0.1	Spring
P14	4/21/05	Spring05	0.012				0.33	Alfalfa	1	0.6	Spring
P14	6/30/05	Summer05	0.025		4.1	1.2	0.98	Corn	1	3.3	Summer
P14	9/1/05	Summer05	0.009		3.6	0.9	0.91	Corn	0	1.5	Summer
P14	10/12/05	Fall05	0.106	0.600	3.6	9.0	0.77	Corn	0	3.3	Fall
P14	10/29/05	Fall05	0.018	1.285	4.2		0.15	Corn	0	0.0	Fall

P14	11/15/05	Fall05	0.035	2.484	7.6	1.4	0.17	Corn	0	1.4	Fall
P14	12/1/05	Fall05	0.010		4.4	1.7	0.26	Corn	0	0.2	Fall
P14	1/13/06	Winter05/06	0.023		3.8	2.3	0.34	Corn	1	0.1	Winter
P14	2/1/06	Winter05/06	0.002		3.7	1.7	0.24	Corn	1	0.8	Winter
P14	2/20/06	Winter05/06	0.017		10.5	3.3	0.63	Corn	1	0.0	Winter
P14	3/12/06	Winter05/06	0.027		3.4	0.6	0.77	Corn	1	0.0	Winter
P14	3/29/06	Spring06	0.020		4.5	0.1	0.73	Corn	1	0.0	Spring
P14	4/15/06	Spring06	0.019		3.4	0.9	0.69	Corn	1	1.3	Spring
P14	4/30/06	Spring06	0.028		4.2	0.1	0.53	Corn	1	0.0	Spring
P15	11/4/04	Fall04	0.013				0.42	Alfalfa	0	0.5	Fall
P15	11/20/04	Fall04	0.004				0.50	Alfalfa	0	0.4	Fall
.P15	12/4/04	Fall04	0.009				0.15	Alfalfa	0	0.0	Fall
P15	12/16/04	Fall04	0.021				0.15	Alfalfa	0	0.1	Fall
P15	1/30/05	Winter04/05	0.024		3.6	1.2	0.27	Alfalfa	1	0.0	Winter
P15	2/17/05	Winter04/05	0.038			11.5	0.15	Alfalfa	1	0.7	Winter
P15	3/7/05	Winter04/05	0.041		4.0	2.9	0.46	Alfalfa	1	0.6	Winter
P15	3/30/05	Spring05	0.031		3.0	2.3	0.15	Alfalfa	1	3.6	Spring
P15	4/5/05	Spring05	0.019		2.6	1.9	0.15	Alfalfa	0	0.1	Spring
P15	4/21/05	Spring05		1.028	2.1	0.7	0.16	Alfalfa	0	0.6	Spring
P15	5/8/05	Spring05	0.013	0.343	2.8	1.9	0.17	Alfalfa	0	0.0	Spring
P15	6/30/05	Summer05	0.023		3.2	1.1	0.24	Corn	0	3.3	Summer
P15	9/1/05	Summer05	0.009	0.515	2.2	8.2	0.24	Corn	0	1.5	Summer
P15	9/27/05	Fall05	0.036	0.429	3.5	3.4	0.24	Corn	0	2.7	Fall
P15	10/12/05	Fall05	0.131	1.371	4.4	4.9	0.23	Corn	0	3.3	Fall
P15	10/29/05	Fall05	0.009	11.732	3.1	1.4	0.23	Corn	0	0.0	Fall
P15	11/15/05	Fall05	0.084	7.793	4.4	5.9		Corn	0	1.4	Fall
P15	12/1/05	Fall05	0.005		4.3	0.8		Corn	0	0.2	Fall
P15	1/13/06	Winter05/06	0.016		3.6	5.5		Corn	1	0.1	Winter
P15	2/1/06	Winter05/06	0.006		3.6	6.7		Corn	1	0.8	Winter
P15	2/20/06	Winter05/06	0.012		11.2	7.2		Corn	1	0.0	Winter

P15	3/12/06	Winter05/06	0.081		3.6	1.5		Corn	1	0.0	Winter
P15	3/29/06	Spring06	0.012		4.4	1.4		Corn	0	0.0	Spring
P15	4/15/06	Spring06	0.018		3.2	1.9		Corn	0	1.3	Spring
P15	4/30/06	Spring06	0.021		4.1	0.1		Corn	0	0.0	Spring
P16	12/4/04	Fall04	0.002					Alfalfa	0	0.0	Fall
P16	3/30/05	Spring05	0.081		2.7	17.5		Alfalfa	0	3.6	Spring
P16	4/5/05	Spring05	0.027		3.4	4.7		Alfalfa	0	0.1	Spring
P16	4/21/05	Spring05	0.010	0.772	1.1	0.9		Alfalfa	0	0.6	Spring
P16	5/8/05	Spring05	0.013	0.600	1.3	2.8		Alfalfa	0	0.0	Spring
P16	10/29/05	Fall05	0.029		2.3			Alfalfa	0	0.0	Fall
P16	11/15/05	Fall05		3.512	0.2	69.6		Alfalfa	0	1.4	Fall
P16	12/1/05	Fall05	0.536		4.3	8.0		Alfalfa	0	0.2	Fall
P16	1/13/06	Winter05/06	0.069		1.6	3.0		Alfalfa	0	0.1	Winter
P16	2/1/06	Winter05/06	0.026		4.7	4.5		Alfalfa	0	0.8	Winter
P16	3/29/06	Spring06	0.028		3.8	1.2		Alfalfa	0	0.0	Spring
P16	4/15/06	Spring06	0.055		2.6	1.4		Alfalfa	0	1.3	Spring
P16	4/30/06	Spring06	0.037		1.8	0.2		Alfalfa	0	0.0	Spring
P17	11/20/04	Fall04	0.005				0.61	Alfalfa	0	0.4	Fall
P17	1/30/05	Winter04/05	0.027		1.8	2.0	0.32	Alfalfa	1	0.0	Winter
P17	2/17/05	Winter04/05	0.017			44.7	0.15	Alfalfa	1	0.7	Winter
P17	3/7/05	Winter04/05	0.021		2.1	7.4	0.39	Alfalfa	1	0.6	Winter
P17	3/30/05	Spring05	0.007		0.1	29.4	0.15	Alfalfa	1	3.6	Spring
P17	4/5/05	Spring05	0.009		1.5	4.9	0.15	Alfalfa	0	0.1	Spring
P17	4/21/05	Spring05	0.009	0.857	1.0	2.1	0.25	Alfalfa	0	0.6	Spring
P17	5/8/05	Spring05	0.015	0.515	2.4	6.4	0.30	Alfalfa	0	0.0	Spring
P18	11/20/04	Fall04	0.001		5.3		0.83	Alfalfa	0	0.4	Fall
P18	12/4/04	Fall04	0.014				0.28	Alfalfa	0	0.0	Fall
P18	12/16/04	Fall04	0.021		4.0		0.44	Alfalfa	0	0.1	Fall
P18	1/30/05	Winter04/05	0.026		4.1	0.9	0.50	Alfalfa	1	0.0	Winter
P18	2/17/05	Winter04/05	0.017			1.2	0.60	Alfalfa	1	0.7	Winter

P18	3/7/05	Winter04/05	0.009		5.0	1.7	0.69	Alfalfa	1	0.6	Winter
P18	3/30/05	Spring05	0.021		3.2	1.8	0.15	Alfalfa	1	3.6	Spring
P18	4/5/05	Spring05	0.010		2.5	2.3	0.15	Alfalfa	0	0.1	Spring
P18	4/21/05	Spring05	0.010	1.200	3.5	0.4	0.15	Alfalfa	0	0.6	Spring
P18	5/8/05	Spring05	0.012	2.570	3.9	1.0		Alfalfa	0	0.0	Spring
P18	6/30/05	Summer05	0.023		2.9	4.1		Corn	0	3.3	Summer
P18	9/1/05	Summer05	0.002	0.087	3.3	1.4		Corn	0	1.5	Summer
P18	10/12/05	Fall05	0.087	0.172	3.1	5.0		Corn	0	3.3	Fall
P18	10/29/05	Fall05	0.018		9.0	1.7		Corn	0	0.0	Fall
P18	11/15/05	Fall05	0.057	2.227	4.8	2.0		Corn	0	1.4	Fall
P18	12/1/05	Fall05	0.013		4.9	1.3		Corn	0	0.2	Fall
P18	1/13/06	Winter05/06	0.001		3.5	1.2		Corn	1	0.1	Winter
P18	2/1/06	Winter05/06	0.002		3.6	3.4		Corn	1	0.8	Winter
P18	2/20/06	Winter05/06	0.006		5.2	5.3		Corn	1	0.0	Winter
P18	3/12/06	Winter05/06	0.074		3.9	1.4		Corn	1	0.0	Winter
P18	3/29/06	Spring06	0.012		4.0	0.0		Corn	0	0.0	Spring
P18	4/15/06	Spring06	0.009		3.4	0.8		Corn	0	1.3	Spring
P18	4/30/06	Spring06	0.025			0.2		Corn	0	0.0	Spring
P19	11/5/03	Fall03	0.100					Corn	0	0.0	Fall
P19	11/18/03	Fall03	0.014					Corn	0	0.2	Fall
P19	12/2/03	Fall03	0.084					Corn	0	0.5	Fall
P19	12/13/03	Fall03	0.042					Corn	0	3.5	Fall
P19	1/24/04	Winter03/04	0.025					Corn	0	0.0	Winter
P19	2/6/04	Winter03/04	0.021					Corn	0	0.5	Winter
P19	2/21/04	Winter03/04	0.025					Corn	0	0.3	Winter
P19	3/1/04	Winter03/04	0.031					Corn	0	0.0	Winter
P19	3/5/04	Winter03/04	0.142					Corn	0	0.9	Winter
P19	3/15/04	Winter03/04	0.029					Corn	0	0.0	Winter
P19	3/25/04	Winter03/04	0.020					Corn	0	0.2	Winter
P19	4/14/04	Spring04	0.145	5.173			0.16	Corn	0	3.4	Spring

P19	5/1/04	Spring04	0.006				0.47	Corn	0	0.0	Spring
P19	5/10/04	Spring04	0.021	1.324			0.54	Corn	0	0.8	Spring
P19	7/19/04	Summer04	0.157	2.162			0.84	Corn	0	2.0	Summer
P19	8/2/04	Summer04	0.021	1.567			0.39	Corn	0	0.2	Summer
P19	8/16/04	Summer04	0.011	0.414			0.59	Corn	0	2.6	Summer
P19	9/4/04	Summer04	0.011	0.066			0.69	Corn	0	0.0	Summer
P19	9/19/04	Summer04	0.013	0.299			0.22	Corn	0	5.4	Summer
P19	9/21/04	Summer04	0.014				0.22	Corn	0	0.0	Summer
P19	9/24/04	Fall04	0.011				0.22	Corn	0	0.1	Fall
P19	9/30/04	Fall04	0.013				0.22	Corn	0	3.0	Fall
P19	11/4/04	Fall04	0.017				0.77	Corn	0	0.5	Fall
P19	11/20/04	Fall04	0.033				0.87	Corn	0	0.4	Fall
P19	12/4/04	Fall04	0.012				0.58	Corn	0	0.0	Fall
P19	12/16/04	Fall04	0.018				0.61	Corn	0	0.1	Fall
P19	1/30/05	Winter04/05	0.023		5.2	2.3	0.65	Corn	1	0.0	Winter
P19	2/17/05	Winter04/05	0.019			1.9	0.76	Corn	1	0.7	Winter
P19	3/30/05	Spring05	0.051		3.5	19.4	0.22	Corn	0	3.6	Spring
P19	4/5/05	Spring05	0.043		2.9	6.1	0.22	Corn	1	0.1	Spring
P19	4/21/05	Spring05	0.006	1.285	2.0	1.0	0.55	Corn	1	0.6	Spring
P19	5/8/05	Spring05	0.026	0.686	3.3	1.9		Corn	1	0.0	Spring
P19	10/29/05	Fall05	0.009		4.9	10.7	0.46	Corn	0	0.0	Fall
P19	11/15/05	Fall05	0.029	2.227	3.8	2.1	0.53	Corn	0	1.4	Fall
P19	12/1/05	Fall05	0.005		5.0	0.6		Corn	0	0.2	Fall
P19	1/13/06	Winter05/06	0.001		2.5	1.0		Corn	1	0.1	Winter
P19	2/1/06	Winter05/06	0.006		3.7	0.9		Corn	1	0.8	Winter
P19	2/20/06	Winter05/06	0.007		6.3	4.5		Corn	1	0.0	Winter
P19	3/29/06	Spring06	0.016		4.5	0.0		Corn	1	0.0	Spring
P19	4/15/06	Spring06	0.009		4.0	1.4		Corn	1	1.3	Spring
P19	4/30/06	Spring06	0.019		4.0	0.1		Corn	1	0.0	Spring
P20	11/5/03	Fall03	0.025					Corn	0	0.0	Fall

P20	11/18/03	Fall03	0.020					Corn	0	0.2	Fall
P20	12/2/03	Fall03	0.041					Corn	0	0.5	Fall
P20	12/13/03	Fall03	0.040					Corn	0	3.5	Fall
P20	1/24/04	Winter03/04	0.026					Corn	0	0.0	Winter
P20	2/6/04	Winter03/04	0.014					Corn	0	0.5	Winter
P20	2/21/04	Winter03/04	0.008					Corn	0	0.3	Winter
P20	3/1/04	Winter03/04	0.083					Corn	0	0.0	Winter
P20	3/5/04	Winter03/04	0.052					Corn	0	0.9	Winter
P20	3/15/04	Winter03/04	0.016					Corn	0	0.0	Winter
P20	3/25/04	Winter03/04	0.002					Corn	0	0.2	Winter
P20	4/14/04	Spring04	0.036	10.557			0.17	Corn	0	3.4	Spring
P20	5/1/04	Spring04	0.008	2.102			0.27	Corn	0	0.0	Spring
P20	5/10/04	Spring04	0.011	1.794			0.36	Corn	0	0.8	Spring
P20	7/5/04	Summer04	0.023	1.731				Corn	0	0.1	Summer
P20	7/19/04	Summer04	0.020	2.185				Corn	0	2.0	Summer
P20	8/2/04	Summer04	0.011	1.385				Corn	0	0.2	Summer
P20	8/16/04	Summer04	0.014					Corn	0	2.6	Summer
P20	9/4/04	Summer04	0.007	0.099				Corn	0	0.0	Summer
P20	9/19/04	Summer04	0.015	0.288				Corn	0	5.4	Summer
P20	9/24/04	Fall04	0.016					Corn	0	0.1	Fall
P20	9/30/04	Fall04	0.012					Corn	0	3.0	Fall
P20	10/16/04	Fall04	0.008					Corn	0	2.1	Fall
P20	11/4/04	Fall04	0.019				0.69	Corn	0	0.5	Fall
P20	11/20/04	Fall04	0.010				0.73	Corn	0	0.4	Fall
P20	12/4/04	Fall04	0.006				0.19	Corn	0	0.0	Fall
P20	12/16/04	Fall04	0.021				0.35	Corn	0	0.1	Fall
P20	2/17/05	Winter04/05	0.051			9.2	0.52	Corn	1	0.7	Winter
P20	3/30/05	Spring05	0.027		3.8	9.4	0.19	Corn	1	3.6	Spring
P20	4/5/05	Spring05	0.012		3.1	4.2	0.19	Corn	1	0.1	Spring
P20	4/21/05	Spring05	0.009	1.200	3.8	0.6	0.25	Corn	1	0.6	Spring

P20	5/8/05	Spring05	0.024	3.512	3.9	1.7	0.34	Corn	1	0.0	Spring
P20	6/30/05	Summer05	0.023		3.4	6.8		Corn	1	3.3	Summer
P20	7/20/05	Summer05	0.035		4.3	0.7		Corn	0	0.1	Summer
P20	9/1/05	Summer05	0.002		3.7	0.6		Corn	0	1.5	Summer
P20	9/20/05	Summer05	0.023	0.429	4.2	0.6		Corn	0	0.2	Summer
P20	9/27/05	Fall05	0.011	0.600	3.0	0.7		Corn	0	2.7	Fall
P20	10/12/05	Fall05	0.067	0.258	4.0	4.6		Corn	0	3.3	Fall
P20	10/29/05	Fall05	0.009	1.714	4.4	1.0		Corn	0	0.0	Fall
P20	11/15/05	Fall05	0.028	3.255	5.7	1.2		Corn	0	1.4	Fall
P20	12/1/05	Fall05	0.010		5.2	0.4		Corn	0	0.2	Fall
P20	1/13/06	Winter05/06			4.3	0.7		Corn	1	0.1	Winter
P20	2/1/06	Winter05/06	0.008		3.6	1.9		Corn	1	0.8	Winter
P20	2/20/06	Winter05/06	0.016		10.1	3.6		Corn	1	0.0	Winter
P20	3/12/06	Winter05/06	0.014		4.9	0.2		Corn	1	0.0	Winter
P20	3/29/06	Spring06	0.024		4.5	1.6		Corn	1	0.0	Spring
P20	4/15/06	Spring06	0.017		3.8	0.9		Corn	1	1.3	Spring
P20	4/30/06	Spring06	0.022		4.1	0.0		Corn	1	0.0	Spring
P21	11/5/03	Fall03	0.056					Alfalfa	1	0.0	Fall
P21	11/18/03	Fall03	0.025					Alfalfa	1	0.2	Fall
P21	12/2/03	Fall03	0.237					Alfalfa	1	0.5	Fall
P21	12/13/03	Fall03	0.039					Alfalfa	1	3.5	Fall
P21	1/24/04	Winter03/04	0.067					Alfalfa	1	0.0	Winter
P21	2/6/04	Winter03/04	0.020					Alfalfa	1	0.5	Winter
P21	2/21/04	Winter03/04	0.014					Alfalfa	1	0.3	Winter
P21	3/1/04	Winter03/04	0.006					Alfalfa	1	0.0	Winter
P21	3/5/04	Winter03/04	0.005					Alfalfa	1	0.9	Winter
P21	3/15/04	Winter03/04	0.059					Alfalfa	1	0.0	Winter
P21	3/25/04	Winter03/04	0.027					Alfalfa	1	0.2	Winter
P21	4/14/04	Spring04	0.042	2.599			0.26	Alfalfa	1	3.4	Spring
P21	5/1/04	Spring04	0.021	4.407			0.23	Alfalfa	1	0.0	Spring

P21	5/10/04	Spring04	0.016	2.146			0.40	Alfalfa	1	0.8	Spring
P21	5/27/04	Spring04	0.018				0.41	Alfalfa	1	1.8	Spring
P21	6/10/04	Spring04	0.011	2.039			0.45	Alfalfa	1	0.7	Spring
P21	6/23/04	Summer04	0.057	2.158			0.55	Alfalfa	1	0.1	Summer
P21	7/5/04	Summer04	0.018	1.639			0.37	Alfalfa	0	0.1	Summer
P21	7/19/04	Summer04	0.074	2.185			0.22	Alfalfa	0	2.0	Summer
P21	8/2/04	Summer04	0.074	1.385			0.25	Alfalfa	0	0.2	Summer
P21	8/16/04	Summer04	0.020				0.18	Alfalfa	0	2.6	Summer
P21	9/4/04	Summer04	0.028	0.058			0.21	Alfalfa	0	0.0	Summer
P21	9/19/04	Summer04	0.035	0.288			0.16	Alfalfa	0	5.4	Summer
P21	9/21/04	Summer04	0.063				0.16	Alfalfa	0	0.0	Summer
P21	9/24/04	Fall04	0.040				0.16	Alfalfa	0	0.1	Fall
P21	9/30/04	Fall04	0.049				0.27	Alfalfa	0	3.0	Fall
P21	10/16/04	Fall04	0.074				0.25	Alfalfa	0	2.1	Fall
P21	11/4/04	Fall04	0.003				0.67	Alfalfa	0	0.5	Fall
P21	11/20/04	Fall04	0.004				0.70	Alfalfa	0	0.4	Fall
P21	12/4/04	Fall04	0.053				0.43	Alfalfa	0	0.0	Fall
P21	12/16/04	Fall04	0.102				0.34	Alfalfa	0	0.1	Fall
P21	1/30/05	Winter04/05	0.043		3.5	2.6	0.49	Alfalfa	1	0.0	Winter
P21	2/17/05	Winter04/05	0.068			6.0	0.34	Alfalfa	1	0.7	Winter
P21	3/7/05	Winter04/05	0.018		3.6	3.2	0.56	Alfalfa	1	0.6	Winter
P21	3/30/05	Spring05	0.118		3.1	8.3	0.22	Alfalfa	1	3.6	Spring
P21	4/5/05	Spring05	0.125		3.1	7.6	0.31	Alfalfa	0	0.1	Spring
P21	4/21/05	Spring05	0.001	1.285	3.3	0.3	0.29	Alfalfa	0	0.6	Spring
P21	5/8/05	Spring05	0.024	3.169	3.9	0.8	0.44	Alfalfa	0	0.0	Spring
P21	6/30/05	Summer05	0.022		3.3	16.7	1.03	Corn	0	3.3	Summer
P21	7/20/05	Summer05	0.028		3.2	1.4	0.79	Corn	0	0.1	Summer
P21	9/1/05	Summer05	0.354	0.087	1.5	4.0	0.93	Corn	0	1.5	Summer
P21	9/27/05	Fall05	0.449	0.429	0.8	11.7	0.97	Corn	0	2.7	Fall
P21	10/12/05	Fall05	0.104	0.172	3.1	4.6	0.66	Corn	0	3.3	Fall

P21	10/29/05	Fall05	0.013	11.989	7.3	2.5	0.37	Corn	0	0.0	Fall
P21	11/15/05	Fall05	0.067	1.285	3.2	5.1	0.86	Corn	0	1.4	Fall
P21	12/1/05	Fall05	0.033		3.8	4.7	0.80	Corn	0	0.2	Fall
P21	1/13/06	Winter05/06			1.7	1.1	0.92	Corn	1	0.1	Winter
P21	2/1/06	Winter05/06	0.010		2.8	1.0	0.90	Corn	1	0.8	Winter
P21	2/20/06	Winter05/06	0.013		8.0	2.4	0.99	Corn	1	0.0	Winter
P21	3/12/06	Winter05/06	0.073		3.2	3.0	1.06	Corn	1	0.0	Winter
P21	3/29/06	Spring06	0.006		4.2	0.0	1.05	Corn	0	0.0	Spring
P21	4/15/06	Spring06	0.028		3.4	0.8	1.01	Corn	0	1.3	Spring
P21	4/30/06	Spring06	0.019		3.9	0.0	0.98	Corn	0	0.0	Spring
P22	11/5/03	Fall03	0.029					Alfalfa	0	0.0	Fall
P22	11/18/03	Fall03	0.015					Alfalfa	0	0.2	Fall
P22	12/2/03	Fall03	0.066					Alfalfa	0	0.5	Fall
P22	12/13/03	Fall03	0.025					Alfalfa	0	3.5	Fall
P22	1/24/04	Winter03/04	0.039					Alfalfa	0	0.0	Winter
P22	2/6/04	Winter03/04	0.019					Alfalfa	0	0.5	Winter
P22	2/21/04	Winter03/04	0.010					Alfalfa	0	0.3	Winter
P22	3/15/04	Winter03/04	0.015					Alfalfa	0	0.0	Winter
P22	3/25/04	Winter03/04	0.080					Alfalfa	0	0.2	Winter
P22	4/14/04	Spring04	0.062	2.365			0.15	Alfalfa	1	3.4	Spring
P22	5/1/04	Spring04	0.058	4.407			0.31	Alfalfa	1	0.0	Spring
P22	5/10/04	Spring04	0.012	1.089			0.38	Alfalfa	1	0.8	Spring
P22	5/27/04	Spring04	0.020	0.105			0.24	Alfalfa	1	1.8	Spring
P22	6/10/04	Spring04	0.040	2.039			0.44	Alfalfa	1	0.7	Spring
P22	6/23/04	Summer04	0.073	2.158			0.50	Alfalfa	1	0.1	Summer
P22	7/5/04	Summer04	0.076	1.685				Alfalfa	0	0.1	Summer
P22	7/19/04	Summer04	0.098	2.094				Alfalfa	0	2.0	Summer
P22	8/2/04	Summer04	0.077	1.446				Alfalfa	0	0.2	Summer
P22	8/16/04	Summer04	0.133					Alfalfa	0	2.6	Summer
P22	9/4/04	Summer04	0.073	0.049				Alfalfa	0	0.0	Summer

P22	9/19/04	Summer04	0.021	0.311				Alfalfa	0	5.4	Summer
P22	9/21/04	Summer04	0.018					Alfalfa	0	0.0	Summer
P22	9/24/04	Fall04	0.019					Alfalfa	0	0.1	Fall
P22	9/30/04	Fall04	0.016					Alfalfa	0	3.0	Fall
P22	10/16/04	Fall04	0.014					Alfalfa	0	2.1	Fall
P22	11/4/04	Fall04	0.004				0.65	Alfalfa	0	0.5	Fall
P22	11/20/04	Fall04	0.011				0.68	Alfalfa	0	0.4	Fall
P22	12/4/04	Fall04	0.031				0.43	Alfalfa	0	0.0	Fall
P22	12/16/04	Fall04	0.026				0.50	Alfalfa	0	0.1	Fall
P22	1/30/05	Winter04/05	0.039		4.6	1.8	0.52	Alfalfa	0	0.0	Winter
P22	2/17/05	Winter04/05	0.027			5.6	0.50	Alfalfa	0	0.7	Winter
P22	3/7/05	Winter04/05	0.026		4.4	2.0	0.55	Alfalfa	0	0.6	Winter
P22	3/30/05	Spring05	0.046		2.1	11.7	0.36	Alfalfa	0	3.6	Spring
P22	4/5/05	Spring05	0.043		2.4	3.4	0.36	Alfalfa	0	0.1	Spring
P22	4/21/05	Spring05	0.009	0.943	2.1	2.8	0.36	Alfalfa	0	0.6	Spring
P22	5/8/05	Spring05	0.598	0.857	2.7	8.7	0.35	Alfalfa	0	0.0	Spring
P22	6/30/05	Summer05	0.223		3.7	11.1	0.45	Alfalfa	0	3.3	Summer
P22	7/20/05	Summer05	0.037		2.4	0.5	0.52	Alfalfa	0	0.1	Summer
P22	9/1/05	Summer05		0.258	0.8	10.5	0.36	Alfalfa	0	1.5	Summer
P22	9/20/05	Summer05	0.031	0.258	4.4	0.8	0.87	Alfalfa	0	0.2	Summer
P22	9/27/05	Fall05	0.017	0.429	3.3	5.1	0.57	Alfalfa	0	2.7	Fall
P22	10/12/05	Fall05	0.310	0.258	3.0	9.2	0.43	Alfalfa	0	3.3	Fall
P22	10/29/05	Fall05	0.122		2.2	4.7	0.36	Alfalfa	0	0.0	Fall
P22	11/15/05	Fall05	0.096	1.628	4.9	6.3	0.50	Alfalfa	0	1.4	Fall
P22	12/1/05	Fall05			2.6	18.9	0.49	Alfalfa	0	0.2	Fall
P22	1/13/06	Winter05/06	0.294		0.7	18.4	0.50	Alfalfa	0	0.1	Winter
P22	2/1/06	Winter05/06	0.208		2.0	8.1	0.45	Alfalfa	0	0.8	Winter
P22	2/20/06	Winter05/06	0.012		10.5	7.8	0.58	Alfalfa	0	0.0	Winter
P22	3/12/06	Winter05/06	0.064		2.0	9.6	0.66	Alfalfa	0	0.0	Winter
P22	3/29/06	Spring06	0.128		1.6	9.1	0.66	Alfalfa	0	0.0	Spring

P22	4/15/06	Spring06	0.059		2.5	5.8	0.62	Alfalfa	0	1.3	Spring
P22	4/30/06	Spring06	0.116		1.4	0.5	0.56	Alfalfa	0	0.0	Spring
P23	11/5/03	Fall03	0.027					Alfalfa	0	0.0	Fall
P23	11/18/03	Fall03	0.023					Alfalfa	0	0.2	Fall
P23	12/2/03	Fall03	0.046					Alfalfa	0	0.5	Fall
P23	12/13/03	Fall03	0.025					Alfalfa	0	3.5	Fall
P23	1/24/04	Winter03/04	0.029					Alfalfa	0	0.0	Winter
P23	2/6/04	Winter03/04	0.005					Alfalfa	0	0.5	Winter
P23	2/21/04	Winter03/04	0.001					Alfalfa	0	0.3	Winter
P23	3/15/04	Winter03/04	0.008					Alfalfa	0	0.0	Winter
P23	4/14/04	Spring04	0.049	8.450			0.54	Alfalfa	1	3.4	Spring
P23	5/1/04	Spring04	0.001	0.425			0.63	Alfalfa	1	0.0	Spring
P23	5/10/04	Spring04	0.013	1.794			0.73	Alfalfa	1	0.8	Spring
P23	5/27/04	Spring04	0.005				0.70	Alfalfa	1	1.8	Spring
P23	6/10/04	Spring04	0.016	1.847			0.72	Alfalfa	1	0.7	Spring
P23	6/23/04	Summer04	0.044	1.567			0.85	Alfalfa	1	0.1	Summer
P23	7/5/04	Summer04	0.021	1.845			0.97	Alfalfa	0	0.1	Summer
P23	7/19/04	Summer04	0.016	2.071			0.89	Alfalfa	0	2.0	Summer
P23	8/2/04	Summer04	0.352	6.061			0.75	Alfalfa	0	0.2	Summer
P23	8/16/04	Summer04	0.014				0.82	Alfalfa	0	2.6	Summer
P23	9/4/04	Summer04	0.004	0.049			0.89	Alfalfa	0	0.0	Summer
P23	9/19/04	Summer04	0.034	0.311			0.41	Alfalfa	0	5.4	Summer
P23	9/21/04	Summer04	0.055				0.41	Alfalfa	0	0.0	Summer
P23	9/24/04	Fall04	0.115				0.43	Alfalfa	0	0.1	Fall
P23	9/30/04	Fall04	0.016				0.41	Alfalfa	0	3.0	Fall
P23	10/16/04	Fall04	0.012				0.69	Alfalfa	0	2.1	Fall
P23	11/4/04	Fall04	0.013				0.79	Alfalfa	0	0.5	Fall
P23	12/4/04	Fall04	0.012				0.49	Alfalfa	0	0.0	Fall
P23	12/16/04	Fall04	0.023				0.62	Alfalfa	0	0.1	Fall
P23	1/30/05	Winter04/05	0.025		1.4	0.6	0.73	Alfalfa	0	0.0	Winter

P23	2/17/05	Winter04/05	0.032			5.6	0.51	Alfalfa	0	0.7	Winter
P23	3/7/05	Winter04/05	0.030		3.6	1.9	0.82	Alfalfa	0	0.6	Winter
P23	3/30/05	Spring05	0.377		3.4	3.8	0.41	Alfalfa	0	3.6	Spring
P23	4/5/05	Spring05	0.132		1.8	4.8	0.41	Alfalfa	0	0.1	Spring
P23	4/21/05	Spring05	0.068	0.943	1.5	1.5	0.56	Alfalfa	0	0.6	Spring
P23	5/8/05	Spring05	0.023	0.600	2.9	2.2	0.55	Alfalfa	0	0.0	Spring
P23	6/30/05	Summer05	0.042		2.3	1.6	0.70	Alfalfa	0	3.3	Summer
P23	7/20/05	Summer05	0.068		2.2	0.8	0.81	Alfalfa	0	0.1	Summer
P23	9/1/05	Summer05	0.005	0.087	3.1	1.3	0.49	Alfalfa	0	1.5	Summer
P23	9/27/05	Fall05	0.026	0.857	5.3	1.0	0.75	Alfalfa	0	2.7	Fall
P23	10/12/05	Fall05	0.096	0.087	5.5		0.74	Alfalfa	0	3.3	Fall
P23	10/29/05	Fall05	0.056	3.340	4.5	4.0	0.57	Alfalfa	0	0.0	Fall
P23	11/15/05	Fall05	0.080	2.142	3.6	4.6		Alfalfa	0	1.4	Fall
P23	12/1/05	Fall05	0.232		3.9	5.6		Alfalfa	0	0.2	Fall
P23	1/13/06	Winter05/06	0.072		3.2	2.5		Alfalfa	0	0.1	Winter
P23	2/1/06	Winter05/06	0.026		3.3	4.2		Alfalfa	0	0.8	Winter
P23	2/20/06	Winter05/06	0.016		11.0	3.9		Alfalfa	0	0.0	Winter
P23	3/12/06	Winter05/06	0.078		2.5	2.5		Alfalfa	0	0.0	Winter
P23	3/29/06	Spring06	0.017		4.5	0.2		Alfalfa	0	0.0	Spring
P23	4/15/06	Spring06	0.016		2.7	0.7		Alfalfa	0	1.3	Spring
P23	4/30/06	Spring06	0.033		3.7	0.1		Alfalfa	0	0.0	Spring
P24	12/4/04	Fall04	0.024				0.51	Corn	0	0.0	Fall
P24	12/16/04	Fall04	0.021				0.60	Corn	0	0.1	Fall
P24	2/17/05	Winter04/05	0.024			4.1	0.66	Corn	1	0.7	Winter
P24	3/30/05	Spring05	0.057		3.2	7.0	0.36	Corn	1	3.6	Spring
P24	4/5/05	Spring05	0.019		3.3	4.4	0.10	Corn	1	0.1	Spring
P24	4/21/05	Spring05	0.012	1.028	4.0	0.5	0.64	Corn	1	0.6	Spring
P24	5/8/05	Spring05	0.012	0.686	4.3	1.1	0.64	Corn	1	0.0	Spring
P25	11/4/04	Fall04	0.081				0.70	Corn	0	0.5	Fall
P25	11/20/04	Fall04	0.015		4.6		0.72	Corn	0	0.4	Fall

P25	12/4/04	Fall04	0.022				0.41	Corn	0	0.0	Fall
P25	12/16/04	Fall04	0.016		5.6		0.50	Corn	0	0.1	Fall
P25	1/30/05	Winter04/05	0.031		5.7	1.0	0.59	Corn	1	0.0	Winter
P25	2/17/05	Winter04/05	0.020			0.9	0.57	Corn	1	0.7	Winter
P25	3/7/05	Winter04/05	0.018		4.3	1.9	0.68	Corn	1	0.6	Winter
P25	3/30/05	Spring05	0.017		1.5	3.4	0.23	Corn	1	3.6	Spring
P25	4/5/05	Spring05	0.002		3.3	1.8	0.00	Corn	1	0.1	Spring
P25	4/21/05	Spring05	0.014	1.028	3.5	0.3	0.51	Corn	1	0.6	Spring
P25	5/8/05	Spring05	0.007	1.714	3.1	0.6	0.52	Corn	1	0.0	Spring
P25	6/30/05	Summer05	0.024		3.7	1.8		Corn	1	3.3	Summer
P25	7/20/05	Summer05	0.023		3.1	1.2		Corn	0	0.1	Summer
P25	9/1/05	Summer05	0.007	0.258	2.6	1.1		Corn	0	1.5	Summer
P25	10/12/05	Fall05	0.093	9.420	3.6	4.5		Corn	0	3.3	Fall
P25	10/29/05	Fall05	0.011	4.711	5.9	2.0		Corn	0	0.0	Fall
P25	11/15/05	Fall05	0.025	5.224	7.0	1.3	0.53	Corn	0	1.4	Fall
P25	12/1/05	Fall05	0.005		4.3	0.9	0.92	Corn	0	0.2	Fall
P25	1/13/06	Winter05/06	0.004		4.2	0.9	0.87	Corn	1	0.1	Winter
P25	2/1/06	Winter05/06	0.022		3.2	0.8	1.01	Corn	1	0.8	Winter
P25	2/20/06	Winter05/06	0.013		10.9	3.2	0.81	Corn	1	0.0	Winter
P25	3/12/06	Winter05/06	0.021		2.9	1.4	0.94	Corn	1	0.0	Winter
P25	3/29/06	Spring06	0.016		4.0	0.0	0.88	Corn	1	0.0	Spring
P25	4/15/06	Spring06	0.040		3.6	0.6	0.71	Corn	1	1.3	Spring
P25	4/30/06	Spring06	0.051		4.0	0.1	0.61	Corn	1	0.0	Spring
P26	12/4/04	Fall04	0.026				0.39	Alfalfa	0	0.0	Fall
P26	12/16/04	Fall04	0.028				0.40	Alfalfa	0	0.1	Fall
P26	2/17/05	Winter04/05	0.243			12.2	0.46	Alfalfa	1	0.7	Winter
P26	3/30/05	Spring05	0.086		2.3	11.4	0.15	Alfalfa	1	3.6	Spring
P26	4/5/05	Spring05	0.025		1.6	9.4	0.15	Alfalfa	0	0.1	Spring
P26	6/30/05	Summer05	0.024		3.1	4.8	0.87	Corn	0	3.3	Summer
P26	7/20/05	Summer05	0.027		2.9		0.62	Corn	0	0.1	Summer

P26	9/1/05	Summer05	0.052	0.087	4.8	0.5	0.61	Corn	0	1.5	Summer
P26	9/27/05	Fall05	0.015	0.686	2.1	1.8	0.84	Corn	0	2.7	Fall
P26	10/12/05	Fall05	0.076	0.515	5.0	4.3	0.49	Corn	0	3.3	Fall
P26	10/29/05	Fall05	0.010	3.255	4.4	1.5	0.23	Corn	0	0.0	Fall
P26	11/15/05	Fall05	0.020	4.796	4.5	0.7	0.29	Corn	0	1.4	Fall
P26	12/1/05	Fall05	0.007		3.8	0.7	0.14	Corn	0	0.2	Fall
P26	1/13/06	Winter05/06	0.003		3.4	1.1	0.26	Corn	1	0.1	Winter
P26	2/1/06	Winter05/06			3.3	1.0	0.20	Corn	1	0.8	Winter
P26	2/20/06	Winter05/06	0.013		5.7	1.9	0.35	Corn	1	0.0	Winter
P26	3/12/06	Winter05/06	0.073		3.3	1.8	0.39	Corn	1	0.0	Winter
P26	3/29/06	Spring06	0.016		4.1	0.0	0.39	Corn	0	0.0	Spring
P26	4/15/06	Spring06	0.040		3.5	0.7	0.35	Corn	0	1.3	Spring
P26	4/30/06	Spring06	0.017		3.4	0.1	0.30	Corn	0	0.0	Spring
P26	6/30/05	Summer05	0.027	0.087	2.1	4.6	0.88	Corn	0	3.3	Summer
P26	7/20/05	Summer05	0.029		3.1	3.2	0.57	Corn	0	0.1	Summer
P26	9/1/05	Summer05	0.005	0.258	3.4	0.8	0.71	Corn	0	1.5	Summer
P26	9/27/05	Fall05	0.007	0.943	3.3	3.2	0.95	Corn	0	2.7	Fall
P26	10/12/05	Fall05	0.074	1.114	4.5	2.5	0.46	Corn	0	3.3	Fall
P26	10/29/05	Fall05	0.008	2.827	4.6	7.4	0.12	Corn	0	0.0	Fall
P26	11/15/05	Fall05	0.018	4.197	5.2	4.7	0.03	Corn	0	1.4	Fall
P26	12/1/05	Fall05	0.006		4.3	4.4	0.03	Corn	0	0.2	Fall
P26	1/13/06	Winter05/06	0.003		2.7	5.2	0.03	Corn	1	0.1	Winter
P26	2/1/06	Winter05/06	0.010		2.8	1.0	0.04	Corn	1	0.8	Winter
P26	2/20/06	Winter05/06	0.017		8.3	6.2	0.17	Corn	1	0.0	Winter
P26	3/12/06	Winter05/06	0.077		2.9	5.8	0.04	Corn	1	0.0	Winter
P26	3/29/06	Spring06	0.038		2.2	4.1	0.03	Corn	0	0.0	Spring
P26	4/15/06	Spring06	0.038		2.8	1.3	0.60	Corn	0	1.3	Spring
P26	4/30/06	Spring06	0.017		3.2	0.1	0.88	Corn	0	0.0	Spring
P27	3/30/05	Spring05	0.038		2.5	5.5	0.20	Alfalfa	0	3.6	Spring
P27	4/5/05	Spring05	0.022		1.1	5.6	0.15	Alfalfa	0	0.1	Spring

P27	11/15/05	Fall05	0.243	2.399	5.4	3.5	0.39	Alfalfa	0	1.4	Fall
P27	12/1/05	Fall05	0.143		4.4	4.4	0.44	Alfalfa	0	0.2	Fall
P27	2/1/06	Winter05/06	0.003		2.0	2.0	0.27	Alfalfa	0	0.8	Winter
P27	4/30/06	Spring06	0.024		3.3	0.1	0.79	Alfalfa	0	0.0	Spring
P28	12/4/04	Fall04	0.015				0.62	Corn	0	0.0	Fall
P28	12/16/04	Fall04	0.022				0.71	Corn	0	0.1	Fall
P28	2/17/05	Winter04/05	0.023			5.4	0.82	Corn	1	0.7	Winter
P28	3/30/05	Spring05	0.042		3.8	12.2	0.43	Corn	1	3.6	Spring
P28	4/5/05	Spring05	0.032		2.0	8.3	0.10	Corn	1	0.1	Spring
P28	5/8/05	Spring05	0.064	1.885			0.71	Corn	1	0.0	Spring
P28	10/29/05	Fall05	0.015	12.417	4.4	14.7	0.45	Corn	0	0.0	Fall
P28	11/15/05	Fall05	0.029	2.912	6.8	6.5		Corn	0	1.4	Fall
P28	12/1/05	Fall05	0.009		4.3	2.4		Corn	0	0.2	Fall
P28	1/13/06	Winter05/06	0.006		2.4	1.4		Corn	1	0.1	Winter
P28	2/1/06	Winter05/06			3.5	1.1		Corn	1	0.8	Winter
P28	2/20/06	Winter05/06	0.013		6.4	4.2		Corn	1	0.0	Winter
P28	3/12/06	Winter05/06	0.077		3.2	1.7		Corn	0	0.0	Winter
P28	3/29/06	Spring06	0.020		2.5	0.0		Corn	1	0.0	Spring
P28	4/15/06	Spring06	0.037		2.8	1.7		Corn	1	1.3	Spring
P28	4/30/06	Spring06	0.027		4.1	0.1		Corn	1	0.0	Spring
P29	2/17/05	Winter04/05	0.041			2.2		Corn	1	0.7	Winter
P29	3/30/05	Spring05	0.028		3.4	4.2		Corn	1	3.6	Spring
P29	4/5/05	Spring05	0.012		3.3	1.9		Corn	1	0.1	Spring
P29	4/21/05	Spring05	0.007	0.943	3.8	0.4		Corn	1	0.6	Spring
P29	5/8/05	Spring05	0.012	2.655	4.7	0.8		Corn	1	0.0	Spring
P29	6/30/05	Summer05	0.028	8.393	2.1	9.5	0.55	Corn	1	3.3	Summer
P29	7/20/05	Summer05	0.028		3.4	0.7	0.35	Corn	0	0.1	Summer
P29	9/1/05	Summer05	0.009	0.087	3.1	1.8	0.45	Corn	0	1.5	Summer
P29	9/20/05	Summer05	0.026	0.600	4.8	1.4	0.50	Corn	0	0.2	Summer
P29	9/27/05	Fall05	0.031	1.371	3.2	4.3	0.59	Corn	0	2.7	Fall

P29	10/12/05	Fall05	0.231	0.258	2.6	2.4	0.15	Corn	0	3.3	Fall
P29	10/29/05	Fall05	0.100	13.102	5.1	5.2	0.15	Corn	0	0.0	Fall
P29	11/15/05	Fall05	0.067	2.227	7.0	9.0	0.24	Corn	0	1.4	Fall
P29	12/1/05	Fall05	0.029		3.9	2.5	0.17	Corn	0	0.2	Fall
P29	1/13/06	Winter05/06	0.074		3.8	4.6	0.30	Corn	1	0.1	Winter
P29	2/1/06	Winter05/06	0.050		2.6	4.1	0.29	Corn	1	0.8	Winter
P29	2/20/06	Winter05/06	0.014		4.3	12.2	0.46	Corn	1	0.0	Winter
P29	3/29/06	Spring06	0.019		0.4	23.2	0.48	Corn	1	0.0	Spring
P29	4/15/06	Spring06	0.035		1.5	17.0	0.43	Corn	1	1.3	Spring
P29	4/30/06	Spring06	0.353		2.0	1.7	0.39	Corn	1	0.0	Spring
P30	11/20/04	Fall04	0.006		3.8		0.60	Alfalfa	0	0.4	Fall
P30	12/4/04	Fall04	0.015				0.16	Alfalfa	0	0.0	Fall
P30	12/16/04	Fall04	0.019		5.0		0.25	Alfalfa	0	0.1	Fall
P30	1/30/05	Winter04/05	0.023		4.1	1.5	0.27	Alfalfa	1	0.0	Winter
P30	2/17/05	Winter04/05	0.019			6.1	0.39	Alfalfa	1	0.7	Winter
P30	3/7/05	Winter04/05	0.018		5.2	1.1	0.45	Alfalfa	1	0.6	Winter
P30	3/30/05	Spring05	0.024		2.0	12.6	0.14	Alfalfa	1	3.6	Spring
P30	4/5/05	Spring05	0.010		2.5	3.1	0.14	Alfalfa	0	0.1	Spring
P30	4/21/05	Spring05	0.007	1.200	2.3	0.3	0.14	Alfalfa	0	0.6	Spring
P30	5/8/05	Spring05	0.013	2.827	4.3	1.2	0.18	Alfalfa	0	0.0	Spring
P30	6/30/05	Summer05	0.022	3.940	0.2	1.9	0.69	Corn	0	3.3	Summer
P30	7/20/05	Summer05	0.029		3.0	1.0	0.63	Corn	0	0.1	Summer
P30	9/1/05	Summer05	0.009	0.087	2.6	1.6	0.57	Corn	0	1.5	Summer
P30	9/27/05	Fall05	0.031	0.686	2.4	2.9	0.80	Corn	0	2.7	Fall
P30	10/12/05	Fall05	0.077	1.114	2.5	10.4	0.50	Corn	0	3.3	Fall
P30	10/29/05	Fall05	0.102	14.044	4.4	3.7	0.31	Corn	0	0.0	Fall
P30	11/15/05	Fall05	0.026	3.597	6.8	1.8		Corn	0	1.4	Fall
P30	12/1/05	Fall05	0.007		3.8	3.0		Corn	0	0.2	Fall
P30	1/13/06	Winter05/06	0.015		3.1	2.0		Corn	0	0.1	Winter
P30	2/1/06	Winter05/06			3.2	2.0		Corn	0	0.8	Winter

P30	2/20/06	Winter05/06	0.012	3.3	4.5	Corn	1	0.0	Winter
P30	3/12/06	Winter05/06	0.015	2.6	2.9	Corn	1	0.0	Winter
P30	3/29/06	Spring06	0.014	3.6	0.1	Corn	0	0.0	Spring
P30	4/15/06	Spring06	0.033	3.0	1.6	Corn	0	1.3	Spring
P30	4/30/06	Spring06	0.022	2.9	0.2	Corn	0	0.0	Spring

APPENDIX B

Source Data from Stream Flow Sampling Sites

Sampling Site (n/a)	Distance (m)	Sampling Day (mm/dd/yy)	SRP (m L^{-1})	NO_3^--N (m L^{-1})	DOC (m L^{-1})	DO (m L^{-1})	Rainfall (cm)	BMPs (n/a)	Season (n/a)	GW $TD_{A,B}$ (m)	GW $SRP_{A,B}$ (m L^{-1})	GW $NO_{3A,B}$ (m L^{-1})	GW $DOC_{A,B}$ (m L^{-1})	GW $DO_{A,B}$ (m L^{-1})
A1	1	10/1/03	0.021				0.20	0	non-growing					
A1	1	10/13/03	0.025				0.00	0	non-growing					
A1	1	11/5/03	0.019				0.00	0	non-growing		0.025			
A1	1	11/18/03	0.005				0.23	0	non-growing		0.011			
A1	1	12/2/03					0.48	0	non-growing		0.031			
A1	1	12/13/03	0.027				3.53	0	non-growing		0.027			
A1	1	1/24/04					0.00	0	non-growing		0.023			
A1	1	2/6/04	0.004				0.51	0	non-growing		0.011			
A1	1	2/21/04					0.25	0	non-growing		0.001			
A1	1	3/1/04					0.00	0	non-growing					
A1	1	3/5/04					0.94	0	non-growing		0.383			
A1	1	3/15/04	0.006				0.00	0	non-growing		0.101			
A1	1	3/25/04	0.002				0.15	0	non-growing		0.070			
A1	1	4/14/04		0.492			3.38	0	non-growing		0.035			
A1	1	5/1/04					0.00	0	growing		0.002			
A1	1	5/10/04	0.016	1.559			0.84	0	growing		0.010			
A1	1	5/27/04	0.008	3.827			1.80	0	growing		0.017			
A1	1	6/10/04	0.006	1.770			0.69	0	growing		0.011			
A1	1	6/23/04	0.036	1.863			0.13	0	growing		0.061			
A1	1	7/5/04	0.020	1.662			0.10	0	growing		0.072			
A1	1	7/19/04	0.007	2.071			1.98	0	growing		0.013			
A1	1	8/2/04	0.018	1.324			0.15	0	growing		0.011			

A1	1	8/16/04	0.003				2.59	0	growing	0.009		
A1	1	9/4/04	0.007	0.058			0.00	0	growing	0.043		
A1	1	9/19/04	0.023	0.311			5.38	0	growing	0.053		
A1	1	9/21/04	0.011				0.00	0	growing	0.026		
A1	1	9/24/04	0.007				0.05	0	growing	0.019		
A1	1	9/30/04	0.009				2.97	0	growing	0.018		
A1	1	10/16/04					2.11	0	non-growing	0.153		
A1	1	11/4/04	0.001				0.46	0	non-growing	0.008		
A1	1	11/20/04	0.008				0.36	0	non-growing	0.007		
A1	1	12/4/04	0.005				0.00	0	non-growing	0.129		
A1	1	12/16/04	0.021				0.05	0	non-growing	0.064		
A1	1	1/30/05	0.022		0.9	6.8	0.00	0	non-growing	0.017	2.1	1.7
A1	1	2/17/05	0.019		1.5		0.66	0	non-growing	0.127	1.7	
A1	1	3/7/05	0.017		1.6	8.0	0.56	0	non-growing	0.018	1.6	4.0
A1	1	3/29/05	0.019		1.4	5.0	3.63	0	non-growing	0.031	1.7	3.7
A1	1	4/5/05	0.010		0.6	3.8	0.10	0	non-growing	0.018	0.7	2.7
A1	1	4/21/05	0.010	0.157	0.5	5.6	0.56	0	non-growing	0.020	0.6	2.2
A1	1	5/8/05	0.015	0.099	0.7	5.3	0.00	0	growing	0.017	1.0	2.9
A1	1	6/1/05					0.00	0	growing			
A1	1	6/30/05					3.30	0	growing	0.134		
A1	1	7/20/05					0.05	0	growing			
A1	1	9/1/05					1.50	0	growing			
A1	1	9/20/05					0.18	0	growing			
A1	1	9/27/05					2.69	1	growing			
A1	1	10/12/05		0.172	2.9	4.4	3.25	1	non-growing	0.084	3.5	3.6
A1	1	10/29/05	0.007		4.3	5.2	0.00	1	non-growing	0.061	1.7	4.1
A1	1	11/15/05	0.014		4.2	8.4	1.40	1	non-growing	0.061	1.4	3.7
A1	1	12/1/05	0.002		1.1	5.7	0.15	1	non-growing	0.034	1.2	5.3
A1	1	1/13/06	0.013		0.8	4.4	0.13	1	non-growing	0.010	1.1	2.9
A1	1	2/1/06	0.004		1.1	3.9	0.84	1	non-growing	0.007	2.4	3.4
A1	1	2/20/06	0.004		3.1	10.4	0.00	1	non-growing	0.009	4.5	10.5

A1	1	3/12/06					0.00	1	non-growing		0.006		0.9	3.7
A1	1	3/29/06					0.00	1	non-growing		0.014		0.0	3.9
A1	1	4/15/06	0.010		0.9	3.7	1.30	1	non-growing		0.024		0.8	2.8
A1	1	4/30/06	0.013		0.2	4.6	0.00	1	non-growing		0.033		0.1	3.4
A2	228	10/1/03	0.022				0.20	0	non-growing					
A2	228	10/13/03	0.024				0.00	0	non-growing					
A2	228	11/5/03	0.025				0.00	0	non-growing		0.025			
A2	228	11/18/03	0.008				0.23	0	non-growing		0.011			
A2	228	12/2/03	0.034				0.48	0	non-growing		0.031			
A2	228	12/13/03	0.027				3.53	0	non-growing		0.027			
A2	228	1/24/04	0.027				0.00	0	non-growing		0.023			
A2	228	2/6/04	0.013				0.51	0	non-growing		0.011			
A2	228	2/21/04					0.25	0	non-growing		0.001			
A2	228	3/1/04					0.00	0	non-growing					
A2	228	3/5/04					0.94	0	non-growing		0.383			
A2	228	3/15/04					0.00	0	non-growing		0.101	2.365		
A2	228	3/25/04	0.008				0.15	0	non-growing		0.070	1.682		
A2	228	4/14/04	0.023	1.897			3.38	0	non-growing	0.76	0.035	1.207		
A2	228	5/1/04	0.003				0.00	0	growing	0.68	0.002			
A2	228	5/10/04	0.012	1.089			0.84	0	growing	0.66	0.010	1.693		
A2	228	5/27/04	0.022				1.80	0	growing	0.78	0.017	1.936		
A2	228	6/10/04	0.005	1.808			0.69	0	growing	0.77	0.011			
A2	228	6/23/04	0.035	2.158			0.13	0	growing	0.92	0.061	2.707		
A2	228	7/5/04	0.025	1.731			0.10	0	growing	0.91	0.072	1.628		
A2	228	7/19/04	0.012	2.162			1.98	0	growing	0.81	0.013	1.417		
A2	228	8/2/04	0.018				0.15	0	growing	0.60	0.011	0.058		
A2	228	8/16/04	0.009				2.59	0	growing	0.73	0.009	0.288		
A2	228	9/4/04	0.011	0.066			0.00	0	growing	0.83	0.043			
A2	228	9/19/04	0.023				5.38	0	growing	0.39	0.053			
A2	228	9/21/04	0.021				0.00	0	growing	0.53	0.026			
A2	228	9/24/04	0.013				0.05	0	growing	0.65	0.019			

A2	228	9/30/04	0.017				2.97	0	growing	0.68	0.018			
A2	228	10/16/04	0.004				2.11	0	non-growing	0.65	0.153			
A2	228	11/4/04	0.035				0.46	0	non-growing	0.77	0.008			
A2	228	11/20/04	0.012				0.36	0	non-growing	0.85	0.007			
A2	228	12/4/04	0.018				0.00	0	non-growing	0.49	0.129			
A2	228	12/16/04	0.025				0.05	0	non-growing	0.56	0.064			
A2	228	1/30/05	0.028		1.3	6.5	0.00	0	non-growing	0.61	0.017		3.3	2.2
A2	228	2/17/05	0.020		1.0		0.66	0	non-growing	0.69	0.127		4.8	
A2	228	3/7/05	0.020		1.2	7.6	0.56	0	non-growing	0.76	0.018		1.5	3.8
A2	228	3/29/05	0.020		2.1	4.7	3.63	0	non-growing	0.50	0.031	0.857	13.2	2.6
A2	228	4/5/05	0.009		0.7	4.2	0.10	0	non-growing	0.51	0.018	0.600	7.8	1.8
A2	228	4/21/05	0.011	0.181	0.7	5.0	0.56	0	non-growing	0.69	0.020		1.1	2.5
A2	228	5/8/05	0.021	0.115	0.9	4.9	0.00	0	growing	0.68	0.017		2.3	2.8
A2	228	6/1/05	0.017		1.2	4.8	0.00	0	growing					
A2	228	6/30/05	0.033		0.9	3.9	3.30	0	growing	0.89	0.134		5.1	3.5
A2	228	7/20/05	0.035		0.3	6.7	0.05	0	growing	1.07				
A2	228	9/1/05	0.005	0.087	1.1	4.3	1.50	0	growing	1.11				
A2	228	9/20/05					0.18	0	growing	1.23				
A2	228	9/27/05					2.69	1	growing	1.23				
A2	228	10/12/05		0.087	3.6	4.1	3.25	1	non-growing	1.07	0.084		3.5	3.6
A2	228	10/29/05	0.020			5.7	0.00	1	non-growing	0.64	0.061		2.1	5.2
A2	228	11/15/05	0.027		1.7	4.4	1.40	1	non-growing	0.46	0.061		2.0	4.1
A2	228	12/1/05	0.004		1.3	6.1	0.15	1	non-growing	0.43	0.034		1.2	4.9
A2	228	1/13/06	0.007		0.8	4.8	0.13	1	non-growing	0.52	0.010		1.1	4.2
A2	228	2/1/06			1.1	4.4	0.84	1	non-growing	0.50	0.007		5.3	2.9
A2	228	2/20/06	0.008		3.8	11.0	0.00	1	non-growing	0.63	0.009		4.0	10.8
A2	228	3/12/06	0.006		0.4	4.2	0.00	1	non-growing	0.72	0.006		0.9	3.7
A2	228	3/29/06	0.022		1.4	6.0	0.00	1	non-growing	0.66	0.014		0.2	4.4
A2	228	4/15/06	0.010		1.6	4.5	1.30	1	non-growing	0.61	0.024		6.7	2.6
A2	228	4/30/06	0.015		0.1	4.7	0.00	1	non-growing	0.51	0.033		0.1	3.2
A3	331	10/1/03					0.20	0	non-growing					

A3	331	10/13/03			0.00	0	non-growing			
A3	331	11/5/03	0.043		0.00	0	non-growing		0.025	
A3	331	11/18/03	0.028		0.23	0	non-growing		0.011	
A3	331	12/2/03	0.046		0.48	0	non-growing		0.031	
A3	331	12/13/03	0.030		3.53	0	non-growing		0.027	
A3	331	1/24/04	0.092		0.00	0	non-growing		0.023	
A3	331	2/6/04	0.029		0.51	0	non-growing		0.011	
A3	331	2/21/04	0.039		0.25	0	non-growing		0.001	
A3	331	3/1/04	0.001		0.00	0	non-growing			
A3	331	3/5/04			0.94	0	non-growing		0.383	
A3	331	3/15/04	0.013		0.00	0	non-growing		0.101	
A3	331	3/25/04	0.023		0.15	0	non-growing		0.070	
A3	331	4/14/04	0.039	1.663	3.38	0	non-growing	0.76	0.035	2.541
A3	331	5/1/04	0.003	0.425	0.00	0	growing	0.68	0.002	0.949
A3	331	5/10/04	0.023	1.324	0.84	0	growing	0.66	0.010	1.618
A3	331	5/27/04	0.056		1.80	0	growing	0.78	0.017	
A3	331	6/10/04	0.013	2.117	0.69	0	growing	0.77	0.011	1.789
A3	331	6/23/04	0.032	2.306	0.13	0	growing	0.92	0.061	1.936
A3	331	7/5/04	0.020	1.822	0.10	0	growing	0.91	0.072	
A3	331	7/19/04	0.011	2.139	1.98	0	growing	0.81	0.013	2.435
A3	331	8/2/04	0.022	1.506	0.15	0	growing	0.60	0.011	1.567
A3	331	8/16/04	0.004		2.59	0	growing	0.73	0.009	1.417
A3	331	9/4/04	0.010	0.082	0.00	0	growing	0.83	0.043	0.083
A3	331	9/19/04	0.025	0.311	5.38	0	growing	0.39	0.053	0.319
A3	331	9/21/04	0.018		0.00	0	growing	0.53	0.026	0.600
A3	331	9/24/04	0.015		0.05	0	growing	0.65	0.019	
A3	331	9/30/04	0.023		2.97	0	growing	0.68	0.018	
A3	331	10/16/04	0.015		2.11	0	non-growing	0.65	0.153	
A3	331	11/4/04	0.026		0.46	0	non-growing	0.77	0.008	
A3	331	11/20/04	0.060		0.36	0	non-growing	0.85	0.007	
A3	331	12/4/04	0.012		0.00	0	non-growing	0.49	0.129	

A3	331	12/16/04	0.029				0.05	0	non-growing	0.56	0.064			
A3	331	1/30/05	0.025		1.0		0.00	0	non-growing	0.61	0.017		3.3	2.2
A3	331	2/17/05	0.022		1.0		0.66	0	non-growing	0.69	0.127		4.8	
A3	331	3/7/05	0.035		1.5	7.7	0.56	0	non-growing	0.76	0.018		1.5	3.8
A3	331	3/29/05	0.025		1.7	4.9	3.63	0	non-growing	0.50	0.031		13.2	2.6
A3	331	4/5/05	0.027		4.8	3.6	0.10	0	non-growing	0.51	0.018		7.8	1.8
A3	331	4/21/05	0.047	0.157	0.6	6.1	0.56	0	non-growing	0.69	0.020	0.943	1.1	2.5
A3	331	5/8/05	0.013	0.099	1.0	5.8	0.00	0	growing	0.68	0.017	0.643	2.3	2.8
A3	331	6/1/05	0.016		1.1	5.2	0.00	0	growing					
A3	331	6/30/05	0.030		1.0	4.7	3.30	0	growing	0.89	0.134		5.1	3.5
A3	331	7/20/05	0.032		0.9	5.7	0.05	0	growing	1.07				
A3	331	9/1/05	0.006		1.4	3.5	1.50	0	growing	1.11				
A3	331	9/20/05					0.18	0	growing	1.23				
A3	331	9/27/05					2.69	1	growing	1.23				
A3	331	10/12/05		0.087	4.3	4.0	3.25	1	non-growing	1.07	0.084		3.5	3.6
A3	331	10/29/05	0.028		1.7	5.2	0.00	1	non-growing	0.64	0.061		2.1	5.2
A3	331	11/15/05	0.077	0.772	2.3	4.6	1.40	1	non-growing	0.46	0.061	0.087	2.0	4.1
A3	331	12/1/05	0.060		1.2	8.0	0.15	1	non-growing	0.43	0.034		1.2	4.9
A3	331	1/13/06	0.017		1.1	5.0	0.13	1	non-growing	0.52	0.010		1.1	4.2
A3	331	2/1/06	0.004		1.5	4.3	0.84	1	non-growing	0.50	0.007		5.3	2.9
A3	331	2/20/06			5.1	11.1	0.00	1	non-growing	0.63	0.009		4.0	10.8
A3	331	3/12/06	0.026		1.3	4.1	0.00	1	non-growing	0.72	0.006		0.9	3.7
A3	331	3/29/06	0.030		2.1	6.7	0.00	1	non-growing	0.66	0.014		0.2	4.4
A3	331	4/15/06			2.4	4.6	1.30	1	non-growing	0.61	0.024		6.7	2.6
A3	331	4/30/06	0.043		0.1	5.1	0.00	1	non-growing	0.51	0.033		0.1	3.2
A4	355	10/1/03	0.145				0.20	0	non-growing					
A4	355	10/13/03	0.113				0.00	0	non-growing					
A4	355	11/5/03	0.141				0.00	0	non-growing		0.025			
A4	355	11/18/03	0.040				0.23	0	non-growing		0.011			
A4	355	12/2/03	0.044				0.48	0	non-growing		0.031			
A4	355	12/13/03	0.033				3.53	0	non-growing		0.027			

A4	355	1/24/04	0.162				0.00	0	non-growing		0.023		
A4	355	2/6/04	0.036				0.51	0	non-growing		0.011		
A4	355	2/21/04	0.181				0.25	0	non-growing		0.001		
A4	355	3/1/04	0.018				0.00	0	non-growing				
A4	355	3/5/04	0.030				0.94	0	non-growing		0.383		
A4	355	3/15/04	0.031				0.00	0	non-growing		0.101		
A4	355	3/25/04	0.036				0.15	0	non-growing		0.070		
A4	355	4/14/04	0.037	1.194			3.38	0	non-growing	0.76	0.035		
A4	355	5/1/04					0.00	0	growing	0.68	0.002		
A4	355	5/10/04	0.018	1.089			0.84	0	growing	0.66	0.010		
A4	355	5/27/04	0.066				1.80	0	growing	0.78	0.017		
A4	355	6/10/04	0.005	1.885			0.69	0	growing	0.77	0.011		
A4	355	6/23/04	0.061	2.010			0.13	0	growing	0.92	0.061		
A4	355	7/5/04	0.121	2.051			0.10	0	growing	0.91	0.072		
A4	355	7/19/04	0.081	2.116			1.98	0	growing	0.81	0.013		
A4	355	8/2/04	0.026	1.506			0.15	0	growing	0.60	0.011		
A4	355	8/16/04	0.029				2.59	0	growing	0.73	0.009		
A4	355	9/4/04	0.205	0.066			0.00	0	growing	0.83	0.043		
A4	355	9/19/04	0.027	0.311			5.38	0	growing	0.39	0.053		
A4	355	9/21/04	0.019				0.00	0	growing	0.53	0.026		
A4	355	9/24/04	0.014				0.05	0	growing	0.65	0.019		
A4	355	9/30/04	0.026				2.97	0	growing	0.68	0.018		
A4	355	10/16/04	0.036				2.11	0	non-growing	0.65	0.153		
A4	355	11/4/04	0.019				0.46	0	non-growing	0.77	0.008		
A4	355	11/20/04	0.035			7.8	0.36	0	non-growing	0.85	0.007		
A4	355	12/4/04	0.029				0.00	0	non-growing	0.49	0.129		
A4	355	12/16/04	0.027			8.9	0.05	0	non-growing	0.56	0.064		
A4	355	1/30/05	0.032		1.3	8.0	0.00	0	non-growing	0.61	0.017	3.3	2.2
A4	355	2/17/05	0.028		8.5		0.66	0	non-growing	0.69	0.127	4.8	
A4	355	3/7/05	0.090		2.0	8.0	0.56	0	non-growing	0.76	0.018	1.5	3.8
A4	355	3/29/05	0.037		2.2	4.8	3.63	0	non-growing	0.50	0.031	13.2	2.6

A4	355	4/5/05	0.029		0.7	3.8	0.10	0	non-growing	0.51	0.018	7.8	1.8
A4	355	4/21/05	0.126	0.157	0.9	5.8	0.56	0	non-growing	0.69	0.020	1.1	2.5
A4	355	5/8/05	0.019	0.082	0.8	5.5	0.00	0	growing	0.68	0.017	2.3	2.8
A4	355	6/1/05	0.049		1.9	4.8	0.00	0	growing				
A4	355	6/30/05	0.073		1.2	4.2	3.30	0	growing	0.89	0.134	5.1	3.5
A4	355	7/20/05	0.072		1.7	4.8	0.05	0	growing	1.07			
A4	355	9/1/05	0.042	0.087	1.7	3.6	1.50	0	growing	1.11			
A4	355	9/20/05					0.18	0	growing	1.23			
A4	355	9/27/05					2.69	1	growing	1.23			
A4	355	10/12/05		0.087	5.1	4.2	3.25	1	non-growing	1.07	0.084	3.5	3.6
A4	355	10/29/05	0.033		1.3	5.8	0.00	1	non-growing	0.64	0.061	2.1	5.2
A4	355	11/15/05	0.070		1.7	4.8	1.40	1	non-growing	0.46	0.061	2.0	4.1
A4	355	12/1/05	0.046		1.5	8.6	0.15	1	non-growing	0.43	0.034	1.2	4.9
A4	355	1/13/06	0.026		0.7	5.0	0.13	1	non-growing	0.52	0.010	1.1	4.2
A4	355	2/1/06	0.009		2.2	4.1	0.84	1	non-growing	0.50	0.007	5.3	2.9
A4	355	2/20/06	0.016		5.2	11.5	0.00	1	non-growing	0.63	0.009	4.0	10.8
A4	355	3/12/06	0.041		1.0	4.2	0.00	1	non-growing	0.72	0.006	0.9	3.7
A4	355	3/29/06	0.016		0.4	6.9	0.00	1	non-growing	0.66	0.014	0.2	4.4
A4	355	4/15/06	0.076		1.2	4.4	1.30	1	non-growing	0.61	0.024	6.7	2.6
A4	355	4/30/06	0.029		0.2	5.3	0.00	1	non-growing	0.51	0.033	0.1	3.2
A5	421	10/1/03					0.20	0	non-growing				
A5	421	10/13/03					0.00	0	non-growing				
A5	421	11/5/03	0.059				0.00	0	non-growing		0.025		
A5	421	11/18/03	0.052				0.23	0	non-growing		0.011		
A5	421	12/2/03	0.044				0.48	0	non-growing		0.031		
A5	421	12/13/03	0.029				3.53	0	non-growing		0.027		
A5	421	1/24/04	0.060				0.00	0	non-growing		0.023		
A5	421	2/6/04	0.007				0.51	0	non-growing		0.011		
A5	421	2/21/04	0.260				0.25	0	non-growing		0.001		
A5	421	3/1/04	0.015				0.00	0	non-growing				
A5	421	3/5/04	0.008				0.94	0	non-growing		0.383		

A5	421	3/15/04	0.214				0.00	0	non-growing		0.101			
A5	421	3/25/04	0.040				0.15	0	non-growing		0.070			
A5	421	4/14/04	0.038	1.663			3.38	0	non-growing	0.76	0.035			
A5	421	5/1/04	0.002	0.425			0.00	0	growing	0.68	0.002			
A5	421	5/10/04	0.024	1.676			0.84	0	growing	0.66	0.010			
A5	421	5/27/04	0.056				1.80	0	growing	0.78	0.017			
A5	421	6/10/04	0.041	1.847			0.69	0	growing	0.77	0.011			
A5	421	6/23/04	0.087	2.084			0.13	0	growing	0.92	0.061			
A5	421	7/5/04	0.271	1.936			0.10	0	growing	0.91	0.072			
A5	421	7/19/04	0.320	2.094			1.98	0	growing	0.85	0.014	2.162		
A5	421	8/2/04	0.037	1.446			0.15	0	growing	0.81	0.009	5.332		
A5	421	8/16/04	0.091				2.59	0	growing	1.00	0.027			
A5	421	9/4/04	0.170	0.066			0.00	0	growing	0.91	0.025	0.049		
A5	421	9/19/04	0.043	0.323			5.38	0	growing	0.50	0.039	0.341		
A5	421	9/21/04	0.022				0.00	0	growing	0.69	0.025	0.343		
A5	421	9/24/04	0.024				0.05	0	growing	0.82	0.061			
A5	421	9/30/04	0.030				2.97	0	growing	0.84	0.016			
A5	421	10/16/04	0.075				2.11	0	non-growing	0.81	0.114			
A5	421	11/4/04	0.025				0.46	0	non-growing	0.95	0.036			
A5	421	11/20/04	0.021				0.36	0	non-growing	0.90	0.022			
A5	421	12/4/04					0.00	0	non-growing	0.71	0.075			
A5	421	12/16/04	0.038				0.05	0	non-growing	0.78	0.042			
A5	421	1/30/05	0.071		1.5	7.7	0.00	0	non-growing	0.61	0.017			
A5	421	2/17/05	0.039		1.9		0.66	0	non-growing	0.72	0.100		1.4	
A5	421	3/7/05	0.144		3.1	7.6	0.56	0	non-growing	0.83	0.023		0.9	7.0
A5	421	3/29/05	0.039		1.6	5.0	3.63	0	non-growing	0.49	0.312		6.2	3.9
A5	421	4/5/05	0.018		0.9	4.3	0.10	0	non-growing	0.46	0.031		3.0	3.1
A5	421	4/21/05	0.034	0.190	1.0	6.3	0.56	0	non-growing	0.77	0.019	0.772	0.3	4.6
A5	421	5/8/05	0.016	0.099	0.9	5.6	0.00	0	growing	0.92	0.022	0.600	1.1	4.2
A5	421	6/1/05	0.035		1.6	5.3	0.00	0	growing					
A5	421	6/30/05	0.235		2.3	2.7	3.30	0	growing	0.95	0.099		1.4	

A5	421	7/20/05	0.200		1.8	8.8	0.05	0	growing	1.07				
A5	421	9/1/05	0.238		3.3	2.2	1.50	0	growing	1.09	0.019	0.515	4.0	4.0
A5	421	9/20/05					0.18	0	growing	1.23				
A5	421	9/27/05					2.69	1	growing	1.23				
A5	421	10/12/05		0.087	6.7	3.9	3.25	1	non-growing	1.06	0.235	2.827	3.0	3.3
A5	421	10/29/05	0.040		1.8	5.7	0.00	1	non-growing	0.72	0.077	3.255	9.0	6.9
A5	421	11/15/05	0.059	2.142	1.4	5.3	1.40	1	non-growing	0.68	0.072	1.029	1.7	5.9
A5	421	12/1/05	0.079		1.0	6.3	0.15	1	non-growing	0.61	0.110		3.6	5.0
A5	421	1/13/06	0.026		1.0	5.0	0.13	1	non-growing	0.68	0.021		1.6	3.3
A5	421	2/1/06	0.011		1.9	4.5	0.84	1	non-growing	0.61	0.020		3.7	2.9
A5	421	2/20/06	0.017		5.1	11.3	0.00	1	non-growing	0.78	0.016		5.0	11.0
A5	421	3/12/06	0.073		0.9	4.2	0.00	1	non-growing	0.84	0.006			1.0
A5	421	3/29/06	0.016		0.5	7.0	0.00	1	non-growing	0.77	0.014		0.0	4.9
A5	421	4/15/06	0.137		1.8	4.3	1.30	1	non-growing	0.68	0.029		1.0	3.0
A5	421	4/30/06	0.028		0.2	5.0	0.00	1	non-growing	0.65	0.042		0.1	4.5
A6	540	10/1/03					0.20	0	non-growing					
A6	540	10/13/03					0.00	0	non-growing					
A6	540	11/5/03	0.052				0.00	0	non-growing		0.025			
A6	540	11/18/03	0.078				0.23	0	non-growing		0.011			
A6	540	12/2/03	0.046				0.48	0	non-growing		0.031			
A6	540	12/13/03	0.034				3.53	0	non-growing		0.027			
A6	540	1/24/04	0.072				0.00	0	non-growing		0.023			
A6	540	2/6/04	0.009				0.51	0	non-growing		0.011			
A6	540	2/21/04	0.028				0.25	0	non-growing		0.001			
A6	540	3/1/04	0.005				0.00	0	non-growing					
A6	540	3/5/04	0.019				0.94	0	non-growing		0.383			
A6	540	3/15/04	0.016				0.00	0	non-growing		0.101			
A6	540	3/25/04	0.040				0.15	0	non-growing		0.070			
A6	540	4/14/04	0.029	1.194			3.38	0	non-growing	0.76	0.035			
A6	540	5/1/04	0.005	0.425			0.00	0	growing	0.68	0.002			
A6	540	5/10/04	0.016	1.324			0.84	0	growing	0.66	0.010			

A6	540	5/27/04	0.076				1.80	0	growing	0.78	0.017			
A6	540	6/10/04	0.009	2.117			0.69	0	growing	0.77	0.011			
A6	540	6/23/04	0.083	2.084			0.13	0	growing	0.92	0.061			
A6	540	7/5/04	0.022	1.914			0.10	0	growing	0.91	0.072			
A6	540	7/19/04	0.323	2.094			1.98	0	growing	0.85	0.014	2.162		
A6	540	8/2/04	0.043	1.506			0.15	0	growing	0.81	0.009	5.332		
A6	540	8/16/04	0.111				2.59	0	growing	1.00	0.027			
A6	540	9/4/04	0.194	0.058			0.00	0	growing	0.91	0.025	0.049		
A6	540	9/19/04	0.030	0.346			5.38	0	growing	0.50	0.039	0.341		
A6	540	9/21/04	0.022				0.00	0	growing	0.69	0.025	0.343		
A6	540	9/24/04	0.013				0.05	0	growing	0.82	0.061			
A6	540	9/30/04	0.040				2.97	0	growing	0.84	0.016			
A6	540	10/16/04	0.071				2.11	0	non-growing	0.81	0.114			
A6	540	11/4/04	0.024				0.46	0	non-growing	0.95	0.036			
A6	540	11/20/04	0.053				0.36	0	non-growing	0.90	0.022			
A6	540	12/4/04	0.019				0.00	0	non-growing	0.71	0.075			
A6	540	12/16/04	0.024				0.05	0	non-growing	0.78	0.042			
A6	540	1/30/05	0.059		1.3	8.0	0.00	0	non-growing	0.61	0.017			
A6	540	2/17/05	0.035				0.66	0	non-growing	0.72	0.100		1.4	
A6	540	3/7/05	0.031		2.0	7.9	0.56	0	non-growing	0.83	0.023		0.9	7.0
A6	540	3/29/05	0.026		2.2	4.8	3.63	0	non-growing	0.49	0.312		6.2	3.9
A6	540	4/5/05	0.027		0.7	4.1	0.10	0	non-growing	0.46	0.031		3.0	3.1
A6	540	4/21/05	0.082	0.206	1.1	6.3	0.56	0	non-growing	0.77	0.019	0.772	0.3	4.6
A6	540	5/8/05	0.018	0.082	1.4	5.9	0.00	0	growing	0.92	0.022	0.600	1.1	4.2
A6	540	6/1/05	0.032		2.0	4.7	0.00	0	growing					
A6	540	6/30/05	0.146		2.5	3.5	3.30	0	growing	0.95	0.099		1.4	
A6	540	7/20/05	0.113	0.087	2.0	4.3	0.05	0	growing	1.07				
A6	540	9/1/05					1.50	0	growing	1.09	0.019	0.515	4.0	4.0
A6	540	9/20/05					0.18	0	growing	1.23				
A6	540	9/27/05					2.69	1	growing	1.23				
A6	540	10/12/05		0.172	9.1	3.8	3.25	1	non-growing	1.06	0.235	2.827	3.0	3.3

A6	540	10/29/05	0.037		1.7	5.3	0.00	1	non-growing	0.72	0.077	3.255	9.0	6.9
A6	540	11/15/05	0.034	0.087	1.6	6.4	1.40	1	non-growing	0.68	0.072	1.029	1.7	5.9
A6	540	12/1/05	0.059		1.4	8.5	0.15	1	non-growing	0.61	0.110		3.6	5.0
A6	540	1/13/06	0.028		1.5	5.5	0.13	1	non-growing	0.68	0.021		1.6	3.3
A6	540	2/1/06	0.011		2.4	3.8	0.84	1	non-growing	0.61	0.020		3.7	2.9
A6	540	2/20/06	0.120		4.6	11.4	0.00	1	non-growing	0.78	0.016		5.0	11.0
A6	540	3/12/06	0.074		2.2	4.3	0.00	1	non-growing	0.84	0.006			1.0
A6	540	3/29/06	0.014		0.9	6.1	0.00	1	non-growing	0.77	0.014		0.0	4.9
A6	540	4/15/06	0.064		2.8	4.2	1.30	1	non-growing	0.68	0.029		1.0	3.0
A6	540	4/30/06	0.025		0.3	6.0	0.00	1	non-growing	0.65	0.042		0.1	4.5
A7	712	10/1/03	0.068				0.20	0	non-growing					
A7	712	10/13/03	0.170				0.00	0	non-growing					
A7	712	11/5/03	0.050				0.00	0	non-growing		0.025			
A7	712	11/18/03	0.087				0.23	0	non-growing		0.011			
A7	712	12/2/03	0.051				0.48	0	non-growing		0.031			
A7	712	12/13/03	0.034				3.53	0	non-growing		0.027			
A7	712	1/24/04	0.091				0.00	0	non-growing		0.023			
A7	712	2/6/04	0.037				0.51	0	non-growing		0.011			
A7	712	2/21/04	0.029				0.25	0	non-growing		0.001			
A7	712	3/1/04	0.003				0.00	0	non-growing					
A7	712	3/5/04	0.010				0.94	0	non-growing		0.383			
A7	712	3/15/04	0.011				0.00	0	non-growing		0.101			
A7	712	3/25/04	0.115				0.15	0	non-growing		0.070			
A7	712	4/14/04	0.032	2.014			3.38	0	non-growing	0.76	0.035			
A7	712	5/1/04		0.425			0.00	0	growing	0.68	0.002			
A7	712	5/10/04	0.022	1.676			0.84	0	growing	0.66	0.010			
A7	712	5/27/04	0.041				1.80	0	growing	0.78	0.017			
A7	712	6/10/04	0.032	1.962			0.69	0	growing	0.77	0.011			
A7	712	6/23/04	0.072	2.232			0.13	0	growing	0.92	0.061			
A7	712	7/5/04	0.173	1.914			0.10	0	growing	1.02	0.072			
A7	712	7/19/04	0.354	2.071			1.98	0	growing	0.97	0.014	2.162		

A7	712	8/2/04	0.042	1.506			0.15	0	growing	1.03	0.009	5.302		
A7	712	8/16/04	0.117				2.59	0	growing	1.09	0.018	1.816		
A7	712	9/4/04	0.099	0.074			0.00	0	growing	0.89	0.019	0.054		
A7	712	9/19/04	0.026	0.335			5.38	0	growing	0.62	0.029	0.323		
A7	712	9/21/04	0.022				0.00	0	growing	0.74	0.027	0.372		
A7	712	9/24/04	0.023				0.05	0	growing	0.92	0.040	0.619		
A7	712	9/30/04	0.024				2.97	0	growing	0.89	0.017			
A7	712	10/16/04					2.11	0	non-growing	1.08	0.063			
A7	712	11/4/04	0.026				0.46	0	non-growing	0.97	0.036			
A7	712	11/20/04	0.032			9.2	0.36	0	non-growing	0.98	0.017			
A7	712	12/4/04	0.011				0.00	0	non-growing	0.86	0.044			
A7	712	12/16/04	0.026			8.2	0.05	0	non-growing	0.92	0.030			
A7	712	1/30/05	0.070		0.9	6.8	0.00	0	non-growing	0.89	0.017		4.9	2.5
A7	712	2/17/05	0.029		0.2		0.66	0	non-growing	0.88	0.060			2.7
A7	712	3/7/05	0.061		2.0	7.5	0.56	0	non-growing	0.88	0.025		6.1	3.0
A7	712	3/29/05	0.026		1.4	5.8	3.63	0	non-growing	0.67	0.172		3.7	5.1
A7	712	4/5/05	0.027		0.9	4.4	0.10	0	non-growing	0.65	0.025		3.0	2.6
A7	712	4/21/05	0.053	0.190	1.0	6.3	0.56	0	non-growing	0.77	0.015	0.900	4.5	0.3
A7	712	5/8/05	0.029	0.082	0.8	5.8	0.00	0	growing	1.01	0.018	0.900	4.4	0.9
A7	712	6/1/05	0.020		2.1	5.1	0.00	0	growing					
A7	712	6/30/05	0.080		2.2	4.7	3.30	0	growing	0.95	0.099			1.4
A7	712	7/20/05	0.057		1.7	5.9	0.05	0	growing	1.07				
A7	712	9/1/05	0.006	0.087	1.0	4.3	1.50	0	growing	1.09	0.019	0.515	4.0	4.0
A7	712	9/20/05					0.18	0	growing	1.23				
A7	712	9/27/05		0.772	2.6	1.3	2.69	1	growing	1.23				
A7	712	10/12/05	0.196	0.087	4.6	4.3	3.25	1	non-growing	1.09	0.203	2.827	3.3	3.0
A7	712	10/29/05	0.025		1.7	5.2	0.00	1	non-growing	0.78	0.063	3.255	6.9	9.0
A7	712	11/15/05	0.031	0.600	1.9	5.1	1.40	1	non-growing	0.78	0.072	1.029	5.9	1.7
A7	712	12/1/05	0.026		1.4	6.1	0.15	1	non-growing	0.63	0.076		5.0	3.6
A7	712	1/13/06	0.001		0.9	5.2	0.13	1	non-growing	0.75	0.021		3.3	1.6
A7	712	2/1/06	0.007		2.2	3.3	0.84	1	non-growing	0.73	0.015		2.9	3.7

A7	712	2/20/06	0.024		3.2	11.8	0.00	1	non-growing	0.95	0.016		11.0	5.0
A7	712	3/12/06	0.072		1.4	4.2	0.00	1	non-growing	1.00	0.006		1.0	
A7	712	3/29/06	0.020		0.9	5.8	0.00	1	non-growing	0.77	0.014		4.9	0.0
A7	712	4/15/06	0.018		1.3	4.8	1.30	1	non-growing	0.84	0.029		3.0	1.0
A7	712	4/30/06	0.017		0.1	5.3	0.00	1	non-growing	0.82	0.042		4.5	0.1
B1	1	10/1/03	0.026				0.20	0	non-growing					
B1	1	10/13/03	0.109				0.00	0	non-growing					
B1	1	11/5/03	0.026				0.00	0	non-growing					
B1	1	11/18/03	0.012				0.23	0	non-growing					
B1	1	12/2/03	0.031				0.48	0	non-growing					
B1	1	12/13/03	0.270				3.53	0	non-growing					
B1	1	1/24/04	0.034				0.00	0	non-growing					
B1	1	2/6/04	0.014				0.51	0	non-growing					
B1	1	2/21/04	0.018				0.25	0	non-growing					
B1	1	3/1/04	0.005				0.00	0	non-growing					
B1	1	3/5/04	0.001				0.94	0	non-growing					
B1	1	3/15/04	0.005				0.00	0	non-growing					
B1	1	3/25/04	0.011				0.15	0	non-growing					
B1	1	4/14/04	0.021	1.780			3.38	0	non-growing			2.541		
B1	1	5/1/04	0.001	0.630			0.00	0	growing			0.949		
B1	1	5/10/04	0.017	1.790			0.84	0	growing			1.618		
B1	1	5/27/04	0.023				1.80	0	growing					
B1	1	6/10/04					0.69	0	growing			1.789		
B1	1	6/23/04					0.13	0	growing			1.936		
B1	1	7/5/04					0.10	0	growing					
B1	1	7/19/04					1.98	0	growing			2.344		
B1	1	8/2/04	0.038	1.510			0.15	0	growing	0.87	0.010	4.482		
B1	1	8/16/04	0.070	0.390			2.59	0	growing	1.47	0.004	1.533		
B1	1	9/4/04					0.00	0	growing	0.70	0.012	0.064		
B1	1	9/19/04	0.026	0.330			5.38	0	growing	0.49	0.014	0.314		
B1	1	9/21/04	0.010				0.00	0	growing	0.49	0.013	0.429		

B1	1	9/24/04	0.012				0.05	0	growing	0.58	0.013	1.970		
B1	1	9/30/04	0.014				2.97	0	growing	0.64	0.015	0.925		
B1	1	10/16/04	0.013				2.11	0	non-growing	1.01	0.011			
B1	1	11/4/04	0.007				0.46	0	non-growing	0.42	0.013			
B1	1	11/20/04	0.007				0.36	0	non-growing	0.62	0.007			
B1	1	12/4/04	0.010				0.00	0	non-growing	0.60	0.009			
B1	1	12/16/04	0.027				0.05	0	non-growing	0.68	0.018			
B1	1	1/30/05	0.021		1.5	7.2	0.00	0	non-growing	0.27	0.024		1.2	3.6
B1	1	2/17/05	0.025		0.4		0.66	0	non-growing	0.62	0.025		4.6	
B1	1	3/7/05	0.156		20.4	8.1	0.56	0	non-growing	0.46	0.033		2.2	4.6
B1	1	3/29/05	0.049		3.0	4.8	3.63	0	non-growing	0.49	0.039		5.7	3.3
B1	1	4/5/05	0.023		0.5	3.5	0.10	0	non-growing	0.44	0.019		2.6	3.0
B1	1	4/21/05	0.012	0.210	0.5	5.6	0.56	0	non-growing	0.16	0.009	1.050	0.7	2.1
B1	1	5/8/05					0.00	0	growing	0.78	0.012	0.891	1.6	3.0
B1	1	6/1/05	0.019		1.6	5.8	0.00	0	growing					
B1	1	6/30/05	0.028		0.9	4.1	3.30	0	growing	0.24	0.023		1.1	3.2
B1	1	7/20/05	0.038		0.5	4.8	0.05	0	growing					
B1	1	9/1/05	0.016		0.7	4.3	1.50	0	growing	0.24	0.009	0.515	8.2	2.2
B1	1	9/20/05					0.18	0	growing					
B1	1	9/27/05	0.397	0.430	0.9	4.4	2.69	0	growing	0.24	0.036	0.429	3.4	3.5
B1	1	10/12/05	0.194	0.340	12.9	3.3	3.25	0	non-growing	0.70	0.135	1.457	7.8	4.4
B1	1	10/29/05	0.019		1.0	4.0	0.00	0	non-growing	0.45	0.028	14.558	2.5	2.9
B1	1	11/15/05	0.029	0.340	1.7	5.7	1.40	0	non-growing	0.73	0.084	2.362	37.8	2.3
B1	1	12/1/05	0.007		1.1	5.2	0.15	0	non-growing	0.49	0.140		3.0	4.5
B1	1	1/13/06			1.2	4.0	0.13	0	non-growing	0.72	0.043		4.3	2.6
B1	1	2/1/06	0.059		2.2	3.7	0.84	0	non-growing	0.73	0.011		4.4	4.0
B1	1	2/20/06	0.004		5.4	10.4	0.00	0	non-growing	1.31	0.012		7.2	11.2
B1	1	3/12/06	0.059		2.0	3.8	0.00	0	non-growing	1.31	0.081		1.5	3.6
B1	1	3/29/06	0.010		2.6	7.0	0.00	0	non-growing		0.020		1.3	4.1
B1	1	4/15/06	0.009		2.2	3.6	1.30	0	non-growing	1.31	0.037		1.7	2.9
B1	1	4/30/06	0.012		0.5	2.3	0.00	0	non-growing	1.16	0.029		0.2	3.0

B2	65	10/1/03				0.20	0	non-growing			
B2	65	10/13/03				0.00	0	non-growing			
B2	65	11/5/03	0.026			0.00	0	non-growing			
B2	65	11/18/03	0.016			0.23	0	non-growing			
B2	65	12/2/03	0.031			0.48	0	non-growing			
B2	65	12/13/03	0.249			3.53	0	non-growing			
B2	65	1/24/04	0.027			0.00	0	non-growing			
B2	65	2/6/04	0.004			0.51	0	non-growing			
B2	65	2/21/04	0.014			0.25	0	non-growing			
B2	65	3/1/04				0.00	0	non-growing			
B2	65	3/5/04	0.002			0.94	0	non-growing			
B2	65	3/15/04	0.007			0.00	0	non-growing			
B2	65	3/25/04	0.010			0.15	0	non-growing			
B2	65	4/14/04	0.023	1.900		3.38	0	non-growing			4.889
B2	65	5/1/04		2.100		0.00	0	growing			2.206
B2	65	5/10/04	0.014			0.84	0	growing			1.626
B2	65	5/27/04	0.011			1.80	0	growing			0.105
B2	65	6/10/04	0.002	1.920		0.69	0	growing			1.901
B2	65	6/23/04	0.036	2.530		0.13	0	growing			1.951
B2	65	7/5/04	0.040	1.940		0.10	0	growing			1.725
B2	65	7/19/04	0.019	2.160		1.98	0	growing			2.216
B2	65	8/2/04	0.028	1.750		0.15	0	growing	0.87	0.010	3.669
B2	65	8/16/04				2.59	0	growing	1.47	0.004	1.253
B2	65	9/4/04	0.021	0.110		0.00	0	growing	0.70	0.012	0.064
B2	65	9/19/04	0.016	0.360		5.38	0	growing	0.49	0.014	0.309
B2	65	9/21/04	0.010			0.00	0	growing	0.49	0.013	0.429
B2	65	9/24/04	0.019			0.05	0	growing	0.58	0.013	1.970
B2	65	9/30/04	0.010			2.97	0	growing	0.64	0.015	0.925
B2	65	10/16/04				2.11	0	non-growing	1.01	0.011	
B2	65	11/4/04	0.006			0.46	0	non-growing	0.42	0.013	
B2	65	11/20/04	0.007		6.5	0.36	0	non-growing	0.61	0.006	

B2	65	12/4/04	0.013				0.00	0	non-growing	0.48	0.010			
B2	65	12/16/04	0.023			5.8	0.05	0	non-growing	0.59	0.019			
B2	65	1/30/05	0.028		1.4		0.00	0	non-growing	0.30	0.026		1.6	2.7
B2	65	2/17/05	0.037		0.2		0.66	0	non-growing	0.39	0.025		13.0	
B2	65	3/7/05	0.023		9.0	7.5	0.56	0	non-growing	0.47	0.032		3.5	4.6
B2	65	3/29/05	0.033		1.9	5.0	3.63	0	non-growing	0.33	0.035		11.5	2.6
B2	65	4/5/05	0.018		1.1	3.6	0.10	0	non-growing	0.30	0.018		2.9	2.7
B2	65	4/21/05	0.175	0.250	0.4	6.0	0.56	0	non-growing	0.25	0.010	1.074	1.0	1.9
B2	65	5/8/05	0.008	0.150	0.8	5.0	0.00	0	growing	0.62	0.013	1.225	2.5	2.9
B2	65	6/1/05	0.013		1.1	8.9	0.00	0	growing					
B2	65	6/30/05	0.023		0.4	4.0	3.30	0	growing	0.61	0.024		1.2	3.7
B2	65	7/20/05	0.029		0.4	4.3	0.05	0	growing					
B2	65	9/1/05	0.019		0.7	4.1	1.50	0	growing	0.58	0.009	0.258	4.6	2.9
B2	65	9/20/05	0.037	0.260	0.6	4.1	0.18	0	growing			1.368		
B2	65	9/27/05	0.198	0.430	0.8	3.1	2.69	0	growing	0.24	0.036	1.368	3.4	3.5
B2	65	10/12/05	0.094		1.8	3.9	3.25	0	non-growing	0.72	0.125	1.368	8.2	4.1
B2	65	10/29/05	0.012		0.9	3.8	0.00	0	non-growing	0.38	0.026	1.368	2.5	3.2
B2	65	11/15/05	0.024	0.510	0.9	3.6	1.40	0	non-growing	0.54	0.060	1.368	25.6	4.1
B2	65	12/1/05	0.005		0.9	4.6	0.15	0	non-growing	0.41	0.114	1.368	2.7	4.4
B2	65	1/13/06	0.005		1.4	5.4	0.13	0	non-growing	0.59	0.036	1.368	3.6	3.0
B2	65	2/1/06	0.011		2.0	4.4	0.84	0	non-growing	0.57	0.009	1.368	3.9	3.9
B2	65	2/20/06	0.007		5.2	10.0	0.00	0	non-growing	0.97	0.015	1.368	5.3	10.9
B2	65	3/12/06	0.061		0.7	3.6	0.00	0	non-growing	1.04	0.054	1.368	1.1	3.5
B2	65	3/29/06	0.014		0.3	6.0	0.00	0	non-growing	0.73	0.020	1.368	0.9	4.2
B2	65	4/15/06	0.029		1.2	4.6	1.30	0	non-growing	1.00	0.031	1.368	1.4	3.1
B2	65	4/30/06	0.015		0.3	4.7	0.00	0	non-growing	0.85	0.029	1.368	0.1	3.4
B3	130	10/1/03	0.019				0.20	0	non-growing					
B3	130	10/13/03	0.021				0.00	0	non-growing					
B3	130	11/5/03	0.024				0.00	0	non-growing		0.043			
B3	130	11/18/03	0.016				0.23	0	non-growing		0.020			
B3	130	12/2/03	0.032				0.48	0	non-growing		0.152			

B3	130	12/13/03	0.254				3.53	0	non-growing		0.032			
B3	130	1/24/04	0.026				0.00	0	non-growing		0.053			
B3	130	2/6/04	0.024				0.51	0	non-growing		0.020			
B3	130	2/21/04	0.002				0.25	0	non-growing		0.012			
B3	130	3/1/04					0.00	0	non-growing		0.006			
B3	130	3/5/04	0.002				0.94	0	non-growing		0.005			
B3	130	3/15/04	0.007				0.00	0	non-growing		0.037			
B3	130	3/25/04	0.006				0.15	0	non-growing		0.054			
B3	130	4/14/04	0.027	1.900			3.38	0	non-growing	0.21	0.052	4.889		
B3	130	5/1/04	0.002	1.470			0.00	0	growing	0.27	0.040	2.206		
B3	130	5/10/04	0.014				0.84	0	growing	0.39	0.014	1.626		
B3	130	5/27/04	0.018				1.80	0	growing	0.33	0.019	0.105		
B3	130	6/10/04		1.850			0.69	0	growing	0.45	0.026	1.901		
B3	130	6/23/04	0.026	2.230			0.13	0	growing	0.53	0.065	1.951		
B3	130	7/5/04	0.029	1.940			0.10	0	growing	0.37	0.047	1.725		
B3	130	7/19/04	0.015	2.070			1.98	0	growing	0.22	0.086	2.216		
B3	130	8/2/04	0.054	1.510			0.15	0	growing	0.66	0.043	3.669		
B3	130	8/16/04	0.063				2.59	0	growing	0.83	0.052	1.253		
B3	130	9/4/04	0.020	0.100			0.00	0	growing	0.46	0.038	0.064		
B3	130	9/19/04	0.023	0.330			5.38	0	growing	0.38	0.021	0.309		
B3	130	9/21/04	0.010				0.00	0	growing	0.38	0.027	0.429		
B3	130	9/24/04	0.015				0.05	0	growing	0.44	0.021	1.970		
B3	130	9/30/04	0.011				2.97	0	growing	0.52	0.024	0.925		
B3	130	10/16/04	0.012				2.11	0	non-growing	0.75	0.028			
B3	130	11/4/04	0.021				0.46	0	non-growing	0.58	0.007			
B3	130	11/20/04	0.002				0.36	0	non-growing	0.68	0.006			5.3
B3	130	12/4/04	0.016				0.00	0	non-growing	0.43	0.019			
B3	130	12/16/04	0.021				0.05	0	non-growing	0.49	0.032			4.0
B3	130	1/30/05	0.033		0.9		0.00	0	non-growing	0.42	0.032		1.7	3.5
B3	130	2/17/05	0.076		0.4		0.66	0	non-growing	0.43	0.054		10.0	
B3	130	3/7/05	0.051		14.0	7.4	0.56	0	non-growing	0.53	0.026		3.0	4.5

B3	130	3/29/05	0.029		1.5	4.5	3.63	0	non-growing	0.27	0.048		10.2	2.7
B3	130	4/5/05	0.019		1.4	3.8	0.10	0	non-growing	0.27	0.031		4.0	2.6
B3	130	4/21/05	0.013	0.820	1.2	8.6	0.56	0	non-growing	0.26	0.008	1.069	1.1	2.3
B3	130	5/8/05	0.009	0.080	0.8	5.9	0.00	0	growing	0.53	0.087	1.222	2.9	3.1
B3	130	6/1/05	0.014		0.8	8.8	0.00	0	growing					
B3	130	6/30/05	0.023		0.5	4.5	3.30	0	growing	0.74	0.052	0.087	6.2	3.2
B3	130	7/20/05	0.028	0.090	1.1	6.9	0.05	0	growing	0.63	0.030		1.7	2.9
B3	130	9/1/05	0.006		0.5	4.3	1.50	0	growing	0.63	0.072	0.247	3.8	2.8
B3	130	9/20/05	0.028	0.260	1.0	4.5	0.18	0	growing	0.87	0.031		0.8	4.4
B3	130	9/27/05	0.164	0.430	1.8	3.4	2.69	0	growing	0.71	0.105		5.0	2.6
B3	130	10/12/05	0.101		2.5	4.6	3.25	0	non-growing	0.60	0.128		6.3	3.9
B3	130	10/29/05	0.011		1.0	5.6	0.00	0	non-growing	0.32	0.030		3.2	4.3
B3	130	11/15/05	0.017	0.770	1.2	6.0	1.40	0	non-growing	0.47	0.054		12.0	4.4
B3	130	12/1/05	0.007		2.3	5.7	0.15	0	non-growing	0.38	0.070		4.4	4.2
B3	130	1/13/06	0.002		2.5	3.5	0.13	0	non-growing	0.50	0.058		4.7	2.6
B3	130	2/1/06	0.073		2.6	3.3	0.84	0	non-growing	0.47	0.031		3.4	3.4
B3	130	2/20/06	0.004		5.2	7.5	0.00	0	non-growing	0.67	0.013		4.9	8.5
B3	130	3/12/06	0.065		0.7	5.1	0.00	0	non-growing	0.71	0.067		3.4	3.2
B3	130	3/29/06	0.010			8.0	0.00	0	non-growing	0.57	0.033		2.0	3.6
B3	130	4/15/06	0.033		1.2	5.2	1.30	0	non-growing	0.76	0.033		1.7	3.1
B3	130	4/30/06	0.018		0.3	4.7	0.00	0	non-growing	0.74	0.035		0.2	3.1
B4	200	10/1/03					0.20	0	non-growing					
B4	200	10/13/03					0.00	0	non-growing					
B4	200	11/5/03	0.022				0.00	0	non-growing		0.043			
B4	200	11/18/03	0.009				0.23	0	non-growing		0.020			
B4	200	12/2/03	0.032				0.48	0	non-growing		0.152			
B4	200	12/13/03	0.231				3.53	0	non-growing		0.032			
B4	200	1/24/04	0.025				0.00	0	non-growing		0.053			
B4	200	2/6/04	0.007				0.51	0	non-growing		0.020			
B4	200	2/21/04	0.003				0.25	0	non-growing		0.012			
B4	200	3/1/04					0.00	0	non-growing		0.006			

B4	200	3/5/04					0.94	0	non-growing		0.005			
B4	200	3/15/04	0.008				0.00	0	non-growing		0.037			
B4	200	3/25/04					0.15	0	non-growing		0.054			
B4	200	4/14/04	0.025	1.430			3.38	0	non-growing	0.21	0.052	4.889		
B4	200	5/1/04		0.630			0.00	0	growing	0.27	0.040	2.206		
B4	200	5/10/04	0.010	2.260			0.84	0	growing	0.39	0.014	1.626		
B4	200	5/27/04	0.146				1.80	0	growing	0.33	0.019	0.105		
B4	200	6/10/04	0.014	2.190			0.69	0	growing	0.45	0.026	1.901		
B4	200	6/23/04	0.045	2.230			0.13	0	growing	0.53	0.065	1.951		
B4	200	7/5/04	0.041	1.910			0.10	0	growing	0.37	0.047	1.725		
B4	200	7/19/04	0.049	2.090			1.98	0	growing	0.22	0.086	2.216		
B4	200	8/2/04	0.046	1.570			0.15	0	growing	0.66	0.043	3.669		
B4	200	8/16/04	0.239				2.59	0	growing	0.83	0.052	1.253		
B4	200	9/4/04	0.063	0.170			0.00	0	growing	0.46	0.038	0.064		
B4	200	9/19/04	0.030	0.320			5.38	0	growing	0.38	0.021	0.309		
B4	200	9/21/04	0.010				0.00	0	growing	0.38	0.027	0.429		
B4	200	9/24/04	0.010				0.05	0	growing	0.44	0.021	1.970		
B4	200	9/30/04	0.016				2.97	0	growing	0.52	0.024	0.925		
B4	200	10/16/04	0.007				2.11	0	non-growing	0.75	0.028			
B4	200	11/4/04	0.023				0.46	0	non-growing	0.58	0.007			
B4	200	11/20/04	0.014				0.36	0	non-growing	0.66	0.006			4.6
B4	200	12/4/04	0.037				0.00	0	non-growing	0.39	0.019			
B4	200	12/16/04	0.094				0.05	0	non-growing	0.46	0.030			4.5
B4	200	1/30/05	0.161		1.0	6.8	0.00	0	non-growing	0.40	0.030		1.7	3.6
B4	200	2/17/05			0.8		0.66	0	non-growing	0.43	0.050		9.6	
B4	200	3/7/05	0.138		6.3	6.4	0.56	0	non-growing	0.52	0.025		2.8	4.6
B4	200	3/29/05	0.051		1.8	5.4	3.63	0	non-growing	0.25	0.045		10.0	2.6
B4	200	4/5/05	0.020		1.1	3.7	0.10	0	non-growing	0.25	0.028		4.1	2.5
B4	200	4/21/05	0.014	0.580	0.5	7.7	0.56	0	non-growing	0.24	0.008	1.069	1.0	2.3
B4	200	5/8/05	0.010	0.120	1.3	6.0	0.00	0	growing	0.47	0.079	1.390	2.7	3.2
B4	200	6/1/05	0.021		1.5	8.9	0.00	0	growing					

B4	200	6/30/05	0.023		0.5	4.3	3.30	0	growing	0.73	0.049	4.140	5.7	2.8
B4	200	7/20/05	0.028	0.090	2.3	6.0	0.05	0	growing	0.63	0.030		1.5	2.9
B4	200	9/1/05	0.006	0.170	0.7	4.4	1.50	0	growing	0.62	0.063	0.215	3.5	2.8
B4	200	9/20/05	0.044	0.510	2.2	10.2	0.18	0	growing	0.87	0.031		0.8	4.4
B4	200	9/27/05	0.202	0.510	2.0	3.4	2.69	0	growing	0.73	0.093		4.7	2.6
B4	200	10/12/05	0.110		4.0	4.6	3.25	0	non-growing	0.59	0.123		6.7	3.7
B4	200	10/29/05	0.014		0.8	5.3	0.00	0	non-growing	0.32	0.036		3.2	4.3
B4	200	11/15/05	0.068	1.200	2.9	4.6	1.40	0	non-growing	0.46	0.072		10.1	4.7
B4	200	12/1/05	0.011		1.2	5.8	0.15	0	non-growing	0.39	0.071		4.2	4.2
B4	200	1/13/06	0.005		2.5	5.4	0.13	0	non-growing	0.50	0.053		4.4	2.7
B4	200	2/1/06	0.006		2.5	4.2	0.84	0	non-growing	0.45	0.028		3.2	3.3
B4	200	2/20/06	0.007		7.2	8.5	0.00	0	non-growing	0.67	0.013		4.8	7.8
B4	200	3/12/06	0.014		4.5	4.5	0.00	0	non-growing	0.71	0.061		3.3	3.1
B4	200	3/29/06	0.010		0.1	7.8	0.00	0	non-growing	0.57	0.030		1.8	3.6
B4	200	4/15/06	0.010		1.1	5.2	1.30	0	non-growing	0.76	0.033		1.7	3.1
B4	200	4/30/06	0.012		0.3	5.3	0.00	0	non-growing	0.74	0.033		0.2	3.1